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# Technique for Calculating Trajectories of Singly Charged Particles in a Static Magnetic Field for Shielding Purposes

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FOREWORD

This report was prepared as an in-house effort by the Propulsion Physics Section, Electric and Advanced Concepts Branch, Propulsion Laboratory, Directorate of Aeromechanics, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio. The work upon which this report is based is documented under Project 5350, "Advanced Concepts for Propulsion," with the author as the chief contributor.

The studies presented began in June 1961 and ended in October 1962.

The author is grateful for the aid and suggestions offered by Mr. T. E. Duvall and other individuals of the Digital Computation Division, Directorate of Systems Dynamic Analysis, ASD.

ABSTRACT

The interactions between a charged particle and an externally applied static magnetic field are reviewed. The elementary effects that involve the introduction of an energetic charged particle into a magnetic field are discussed. Equations are derived for the magnetic flux density and for calculating the trajectories of singly charged particles. Also discussed are the applications of these equations and the boundary conditions. These equations are then adapted to the Fortran program. The use of the Fortran program and the method of data input are explained. Sample problem data, a printout of the program deck, and printouts of the solutions to the problems are also presented.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

FOR THE COMMANDER:



ROBERT E. SUPP  
Chief, Electric and Advanced Propulsion  
Branch  
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## LIST OF SYMBOLS

## SYMBOLS USED IN THEORETICAL EQUATIONS

$\vec{a}$	= acceleration vector
A	= vector potential
b	= radius of a circular coil loop
B	= magnetic flux density
C	= multiplication factor
d	= derivative
D	= additive factor
e	= charge
E(k)	= elliptic integral of the second kind
F	= force
I	= current (amperes)
k	= constant term of elliptic integral
K(k)	= elliptic integral of the first kind
m	= mass of particle
r	= scalar distance
R	= radius of cyclotron
s	= element of length
t	= element of time
u	= unit vector
v	= velocity
w	= angular momentum
X	= co-ordinate
Y	= co-ordinate
Z	= co-ordinate
$\beta$	= angle used in change of variables
$\Delta$	= increment or gradient
$\rho$	= radius in cylindrical co-ordinates
$\left. \begin{matrix} \phi \\ \theta \end{matrix} \right\}$	= angles in spherical co-ordinates

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## SYMBOLS USED IN FORTRAN PROGRAM

A	▪ a trigonometric function
AAAA	▪ multiplication factor
ACOIL	▪ radius of coil
AGMX	▪ maximum configuration of coil (inches)
AHCOIL	▪ radius of coil in zone H (inches)
AHMAX	▪ maximum radius of coil in zone H (inches)
AHMIN	▪ minimum radius of coil in zone H (inches)
B	▪ a trigonometric function
BBBB	▪ an additive term
BN	▪ absolute value of magnetic field strength (webers/meter <sup>2</sup> )
BRHO	▪ radial component of magnetic field strength
BX	▪ X component of magnetic field strength
BY	▪ Y component of magnetic field strength
BZ	▪ Z component of magnetic field strength
CL	▪ speed of light
CONV	▪ conversion factor
DADDZ	▪ derivative
DR	▪ element of distance (inches)
DTETAO	▪ increment of angle (degrees)
DTHETA	▪ increment of angle
DT	▪ element of time
DZH	▪ pitch of coil in zone H (inches)
EOT	▪ energy of particle
IAT	▪ input signal
I	▪ subscript variable
IH	▪ zone number
IHMAX	▪ maximum zone number
IMAX	▪ maximum number of particles
IOT	▪ initial current value (amperes)
ISMAX	▪ maximum number of steps taken ( $\frac{RMAX}{DR} + 1$ ); ISMAX must be an integer.
IT	▪ time quantum
JAT	▪ input signal
LAT	▪ input signal

## SYMBOLS USED IN FORTRAN PROGRAM (Continued)

MMAX	= maximum number of angular increments
MO	= mass of charged particle (kilograms)
RHO	= radius in the xy plane
RMAX	= maximum three-dimensional distance (inches)
THETAO	= angle with respect to Z axis
T	= time
UO	= permeability of free space
VOT	= velocity of particle (meters/second)
VX	= X component of velocity
VY	= Y component of velocity
VZ	= Z component of velocity
WX	= X component of angular momentum
WY	= Y component of angular momentum
WZ	= Z component of angular momentum
XO	= initial X co-ordinate of particle
XS	= X co-ordinate of particle
YO	= initial Y co-ordinate of particle
YS	= Y co-ordinate of particle
Z	= distance between coil loop and particle
ZHCOIL	= location of coil on Z axis
ZHMAX	= maximum zone dimension (inches)
ZHMIN	= minimum dimension of zone (inches)
ZO	= initial Z co-ordinate particle
ZS	= Z co-ordinate of particle

## INTRODUCTION

With the advent of space flight came the introduction and design of manned space vehicles. The realization of the full potential of manned space flight is impaired because of the limitations imposed on the vehicle and its occupants by the dangerous effects of ionizing radiation encountered in space. These principal radiation sources are the Van Allen belts that surround the earth, solar flares that occur periodically with varying intensities and strength, and intergalactic cosmic radiation. In the past, radiation shielding has been considered from the concept of interposing bulk shielding between the occupant of a space vehicle and the source. Interposing bulk shielding increases secondary radiation on the down-stream side of the shield. Therefore, the resultant radiation increases and intensifies the detrimental biological effects which in turn requires even greater bulk shielding with attendant weight increases.

Studies have been made to compute the weight penalties imposed by the bulk shielding requirements (References 1, 2, and 6). These weight estimates are used in arriving at space propulsion system performance criteria. The following study has been made to provide sufficient information to allow the computation of electromagnetic shield weights. These weights may be compared with bulk shielding weights to allow further definitization of space propulsion system criteria.

Shielding or primary radiation sources (energetic free-charged particles) by magnetic fields has been considered by many shielding experts (References 3 and 4). However, shielding by magnetic fields appeared unattractive because of large power requirements and the relative massiveness of the power-source equipment. With the advent of superconductors, this picture changed considerably.

Laboratory experiments have demonstrated that superconductors showing no detectable electrical resistance can generate magnetic fields of 100 to 500 kilogauss with very little expenditure of power. Corresponding current densities range from 1 to  $10^3$  kiloamperes per square centimeter. Large, lightweight, low-power coils will become a reality within a few years, which will make magnetic shielding of charged particles extremely attractive.

Before magnetic shielding can be established, we must be able to compute the magnetic fields of large coils and project the method of computation to the calculations of trajectories of singly charged particles. First, we define the charged particles in a static magnetic field. Then equations are derived for magnetic flux density and for calculations of trajectories of singly charged particles. From these equations and the geometric configuration of the coil, we use the Fortran Program of the IBM 7090 digital computer as the analytical tool to calculate the trajectories. The Fortran code is described in Appendix I; a flow diagram of the program is shown in Figure I-1 of the appendix. To prove the feasibility of our method, we present three basic problems and a slight deviation of one of the problems. The same model was used for all problems.

## CHARGED PARTICLES IN A STATIC MAGNETIC FIELD

When a single particle of charge ( $e$ ) that traverses a magnetic field of flux density ( $B$ ) with velocity ( $v$ ) is considered, the force ( $F$ ) on the particle can be written in vector notations as

$$\vec{F} = e(\vec{v} \times \vec{B})$$

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From Newton's second law, the force is equal to the mass,  $m$ , times the acceleration,  $a$ . By substitution, one can show that

$$\vec{a} = \frac{q}{m} (\vec{v} \times \vec{B}). \quad (1)$$

If the vector of the velocity is exactly normal to  $\vec{B}$ , the acceleration is a maximum. Conversely, if the velocity vector is exactly parallel to  $\vec{B}$ , there is no acceleration.

Suppose a positive ion is moving in a field-free space as shown in Figure 1. If a magnetic field is applied at point A, the acceleration is downward and the particle describes a circular path in the clockwise direction in the plane of the paper. The force on the particle can then be expressed as

$$F = ma = evB.$$

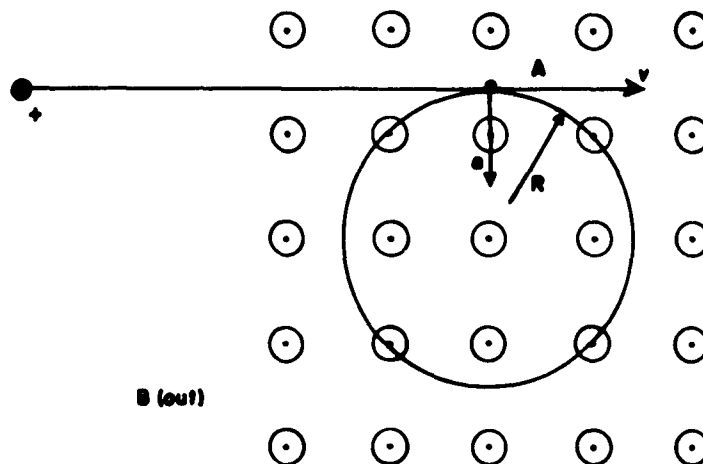


Figure 1. Trajectory of Particle in Magnetic Field

The acceleration can be written as

$$a = \frac{v^2}{R}$$

where  $R$  is the radius of curvature of the particle's trajectory.

Therefore,

$$\frac{mv^2}{R} = evB$$

and

$$R = \frac{mv}{eB}. \quad (2)$$

## DERIVATION OF MAGNETIC FLUX DENSITY

In the preceding equations, the magnetic flux density (B) (Reference 5) is defined as

$$\mathbf{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\mathbf{s} \times \mathbf{r}}{r^3}$$

By introduction of the vector potential (A), the magnetic flux density may be expressed as

$$\mathbf{B} = \nabla \times \mathbf{A}$$

The circular coil loop is illustrated in Figure 2. From Figure 2, s is a coil containing a current I. If this current is considered a circular ring charge, the vector potential A for this configuration may be written in the form

$$\mathbf{A} = \frac{\mu I}{4\pi} \int \frac{d\mathbf{s}}{r}$$

The factor d s is defined as an element of surface and r is defined as the distance from the element of surface to a point at which the vector potential is being computed.

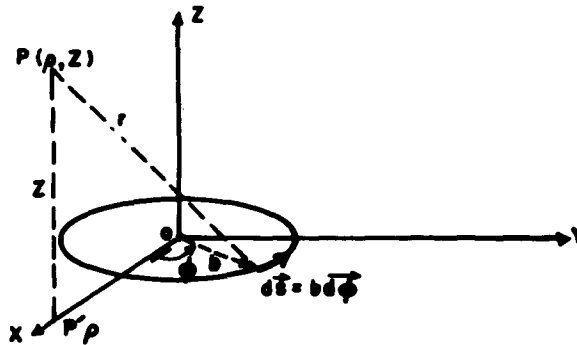


Figure 2. Circular Coil Loop

At point s,

$$ds = b d\phi$$

dφ is given as

$$d\phi = \bar{\mu}_1 \sin \phi d\phi + \bar{\mu}_2 \cos \phi d\phi$$

One can see that

$$\mathbf{A} = \frac{\mu I}{4\pi} \int_0^{2\pi} \frac{(\bar{\mu}_1 \sin \phi d\phi + \bar{\mu}_2 \cos \phi d\phi) b}{\left[ (\rho - b \cos \phi)^2 + (b \sin \phi)^2 + z^2 \right]^{\frac{1}{2}}}$$

where  $\vec{\mu}_1$  and  $\vec{\mu}_2$  are unit vectors in the radial and tangential direction, respectively. The first component is radially directed and is cancelled by the symmetrical element  $(-\phi)$ . The second component is tangential. By a change of variables, one may see that

$$A\phi = \frac{\mu I}{2\pi\rho} \left[ (\rho + b)^2 + z^2 \right]^{\frac{1}{2}} \left[ \left( 1 - \frac{1}{2} k^2 \right) \kappa(k) - E(k) \right] \quad (3)$$

when  $\cos \phi = 2 \sin^2 \beta - 1$ .

The factors  $K(k)$  and  $E(k)$  are elliptic integrals of the first and second kinds, respectively. In cylindrical coordinates (Reference 7),

$$B_\rho = - \frac{\partial A\phi}{\partial z}$$

$$B_z = \frac{1}{\rho} \frac{\partial (\rho A\phi)}{\partial \rho}$$

$$B_\rho = \frac{\mu I}{2\pi} \frac{z}{\rho} \left[ (\rho + b)^2 + z^2 \right]^{-\frac{1}{2}} \left[ -\kappa(k) + \frac{b^2 + \rho^2 + z^2}{(b - \rho)^2 + z^2} E(k) \right] \quad (4)$$

$$B_z = \frac{\mu I}{2\pi} \left[ (\rho + b)^2 + z^2 \right]^{-\frac{1}{2}} \left[ \kappa(k) + \frac{b^2 - \rho^2 - z^2}{(b - \rho)^2 + z^2} E(k) \right] \quad (5)$$

and

$B_\phi = 0$  because of axial symmetry.

Also

$$\rho = \left[ x^2 + y^2 \right]^{\frac{1}{2}}$$

$$B_\rho = \left[ B_x^2 + B_y^2 \right]^{\frac{1}{2}}$$

$$B_x = B_\rho \cos \phi$$

and

$$B_y = B_\rho \sin \phi.$$

These equations, which represent the components of the magnetic field (B), will be used to compute the magnetic flux density of a coil loop at a point in space.

## SOLUTION OF PARTICLE TRAJECTORY

From the equation of acceleration of a charged particle in a magnetic field, the acceleration vector ( $\vec{a}$ ) can be expanded into its respective components as follows:

$$\vec{a} = \frac{e}{m} \vec{v} \times \vec{B}.$$

Since the angular momentum of the particle can be defined as

$$\vec{w} = \frac{e\vec{B}}{m},$$

the components of acceleration can be written as

$$\left. \begin{aligned} a_x &= w_z v_y - w_y v_z \\ a_y &= w_x v_z - w_z v_x \\ a_z &= w_y v_x - w_x v_y \end{aligned} \right\} \quad (6)$$

In considering an approximation to the solution of the three differential equations, assume that the charged particle is acted upon over a period  $\Delta t$ . In this element of time, the components of velocity are shown to be

$$v_x = a_x (\Delta t)$$

$$v_y = a_y (\Delta t)$$

$$v_z = a_z (\Delta t)$$

If the initial location of the particle is  $(x_0, y_0, z_0)$ , the location of the particle after time  $\Delta t$  is

$$\left. \begin{aligned} x &= x_0 + v_x \Delta t \\ y &= y_0 + v_y \Delta t \\ z &= z_0 + v_z \Delta t \end{aligned} \right\} \quad (7)$$

## CONFIGURATION OF COIL

Since the computation of the magnetic field is based on cylindrical co-ordinates, any dipoles must show cylindrical symmetry. An air-core coil can, therefore, be described. See Figure 3. The radius of each coil can vary longitudinally as illustrated in Figure 3. The longitudinal profile of the coil may be portions of cylinders of different radii, or cones, or combinations of these. The variation in the radius of a coil as a function of longitudinal position ( $Z$ ) in these geometries may be expressed as

$$b = (Z_{min} + Z) \frac{db}{dZ} + b_{min}.$$



where the variable  $Z$  is the location of the coil loop in question. If  $\frac{db}{dz}$  is equal to zero, the coil is a cylinder. If  $\frac{db}{dz}$  is not zero, but is either negative or positive,  $b$  describes the radius of a single loop in a conical configuration at position  $Z$ . The  $Z$  can be shown to be

$$Z = Z_{\min} + (n) dz \quad (8)$$

where  $Z_{\min}$  is the location of the first coil in the configuration and  $dz$  is the pitch of the coil. The indexing integer,  $n$ , varies from 0 to  $n_{\max}$ .

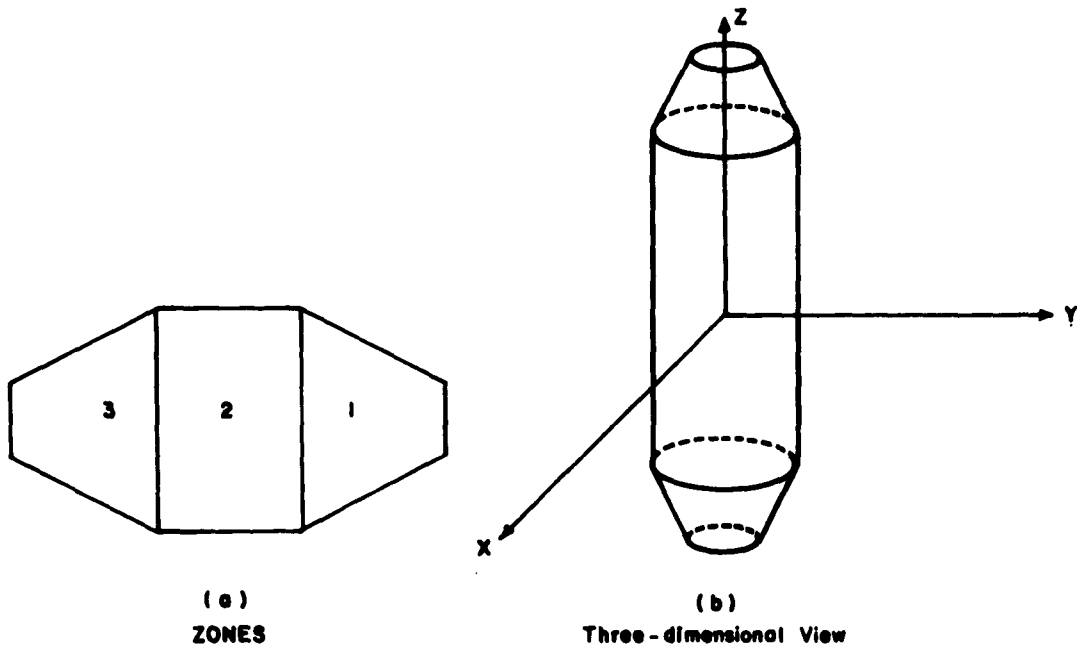


Figure 3. Model of Air Core Coil

#### PROGRAM LOGIC

In superconductor theory, each coil may exist as a separate entity. In computation of the magnetic field  $B$  at a point, each loop contributes to the separate components of magnetic field. As shown in Figure 4, the magnetic field  $B_1$ , at point 1 is assumed to operate on the particle for time  $\Delta t_1$ . After time  $\Delta t_1$ , the particle is at point 2. After  $B_2$  is computed at point 2, the components of acceleration at that point are computed. After time  $\Delta t_2$ , the particle is located at point 3. If the value of the current in the magnetic field computation is of sufficient magnitude, the field will be strong enough to cause the charged particle to deflect away from the coil.

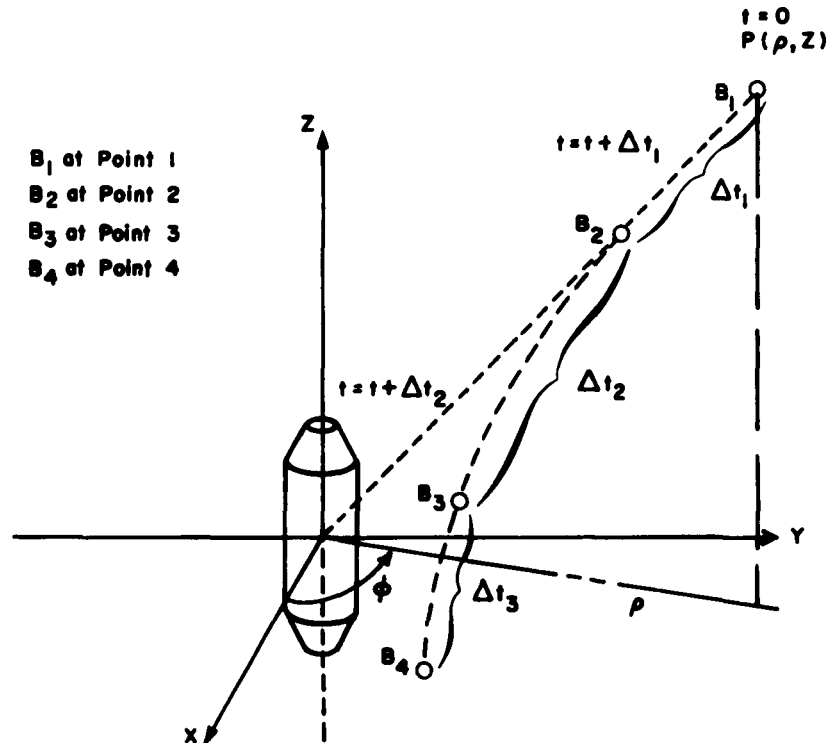


Figure 4. Particle Trajectory

If the value of the current is not of sufficient magnitude, a charged particle will penetrate the coil configuration. We consider this penetration a collision. If the computer detects two simultaneous collisions, we have programmed the computer to check the two points of entry into the coil. If the distance between the two points is greater than  $10^{-6}$  meters, the program will automatically compute an increased value of the current using the expression

$$I_n = C I_{n-1} + D \quad (9)$$

where C is an intuitive multiplication factor for partially determining a new current. The new value of current will be substituted into the magnetic field Equation (5) to determine a new set of field parameters.

The factor D is an additive parameter in the current selection equation; it increases the multiplication factors mentioned in the last two statements. In the program, C is AAA\ and D is BBBB. From previous computer runs, reasonable values of C and D are 7 and 1000, respectively. Smaller changes in the current may be obtained by lowering C.

If the two collision points are identical, the program will not print out more than three trajectories. In this case, the current changing routine will be bypassed. A capability

for changing the incident angle of the particle is built into the program. This routine follows an identical collision-point event as described in the last statement.

Complete trajectories are not necessarily printed out. Only the significant parameters that cause a particle to deflect may be printed. To determine an upper and lower limit to these significant parameters, one must print the parameters of the miss and the last collision hit. See Figure I-1 of Appendix I. If both sets of parameters are identical, the information indicates twin collision points. Of primary interest are the current values.

In a trajectory run, the program computes and prints out approximately 100 lines per minute. A single trajectory constitutes 100 lines of print out.

The program can compute magnetic field strengths about a cylindrical air-core coil. If the axis of the coil corresponds to the Z axis, the value of the magnetic field may be determined at any point on the axis or at any point on the trace of a line that makes an angle  $\theta$  with the Z axis. If the geometric center of the coil corresponds to the center of the coordinate system, the magnetic field at any number of points spaced equidistant from 0 to  $R_{\max}$  on the trace will be computed. The point 0 is included. The values of magnetic field will peak at or near the periphery of the coil loop and will decrease as the distance from the loop to the reference point increases. If the angle  $\theta$  is varied from 0 to  $\pi$  radians, enough information on the magnetic field of the coil may be computed to plot equipotential lines around the coil configuration.

## SAMPLE PROBLEMS

### EXAMPLE 1

As example 1, we will develop a sample problem of computing the trajectory of a charged particle in a static magnetic field. A configuration similar to that shown in Figure 3 was used. The order and makeup of a sample problem deck are shown in Figure 5 (Example 1). Figure 5 shows the information that is necessary to compute and printout a trajectory. The printout is given in Appendix II.

The first card must have seven bits of information. If the control word is not applicable to the type of information desired, then zeros must be punched in that position. These bits of information are used as follows:

1. SMAX is not used in a trajectory run.
2. HMAX indicates the number of zones in which the configuration of the coil is divided. Each zone must have the same coil pitch and slope. The change of coil-loop radius per unit distance along the coil axis defines the slope. The configuration of the coil may be divided into any number of zones up to 999.
3. MMAX is not used in a trajectory run.
4. IMAX indicates the number of particles in this problem.
5. IAT is a switching signal, which determines whether this problem is a trajectory run. A number equal to or greater than 1 will indicate a trajectory run.

[illegible]

**Figure 5. Order of Example 1 Problem**

6. JAT can cause different types of information to be printed. For JAT = 0, the entire particle trajectory will be computed internal to the computer. JAT = 1 indicates the entire trajectory will not be printed. JAT = 2 is used for other types of problems.

7. LAT can cause different types of information to be printed. For LAT = 0 only parameters that caused a particle to miss the coil and the parameters of the last hit are printed. If LAT = 1, the hit and miss data will not be printed. LAT = 2 is used for other types of problems.

In the remaining cards, the input format is the same. The values are input in fields of 13. Only four fields per card are allowed. All information will be stacked continuously as shown in Figure 5.

In the second card, AGMX represents the most distant point from the center of the reference system and is input in inches. The factors AAAA and BBBB cause the coil current to be increased. MO is the rest mass in kilograms of the particle being investigated.

In the third card, DTETAO represents the incremental change in the incident angle from 0 to a maximum of 180 degrees over which the particles will approach the coil. DTHETA, DR, and RMAX are not used in the trajectory routine.

In cards 4 to 8 there are HMAX values of ZHMAX, AHMIN, the coil pitch DZH, the change in coil radius per unit length DA/DZ, the maximum radius of the coils in each zone AHMAX, and the minimum radius of coils in each zone AHMIN, respectively. Cards 4 to 8 represent the coil configuration in its entirety.

After the configuration of the coil as defined in cards 4 to 8, there will be IMAX values of EOT, the particle energy in million electron volts (Mev), followed by the same number of values of VOT, the velocity of the respective particles listed under EOT. Finally, EOT and VOT will be followed by IMAX values of current (IOT). These values are assumed to be great enough to generate magnetic fields of sufficient strength to cause deflection of the particle.

Not shown in the Example 1 sample problem is a card with an asterisk in Column 1 and the word DATA punched in columns 7 to 10. This card precedes the problem deck. All of the information described will follow the binary program deck.

The printout of the sample problem is shown in Appendix II. The significant parameters resulting from this problem are plotted in Figure II-1 of Appendix II immediately following the printout.

Projections into the X-Y plane of a hit and a miss pair of trajectories are shown in Figure II-2 of Appendix II.

## EXAMPLE 2

In the computation of the trajectory of a charged particle in a static magnetic field, the same critical parameters that are plotted from trajectory data in Example 1 may be obtained through a hit or miss printout. The Example 2 problem, shown in Figure 6, has the appropriate values to cause a hit or miss printout. When the first card of a problem deck is changed, information of a hit or miss printout may be obtained as listed in Appendix III.

[illegible]

**Figure 6. Order of Example 2 Problem**

The information of the Example 2 problem is the same as that of Example 1, except in card 1 IMAX and JAT now have the value 2. Cards 8 and 9 now have two values of EOT, VOT, and IOT, respectively. These data are plotted in Figure III-1 of Appendix III. Additional data not tabulated in this report are also plotted in Figure III-1.

The values of IOT and SBN of this printout have no meaning in the hit or miss data. The critical current I is significant.

The critical currents necessary for the magnetic field to deflect charged particles of energy E are taken from Figure III-1 and plotted in Figure III-2. From Figure III-1, it is apparent that the maximum sensible current is that which causes the field to deflect energetic particles with an incident angle of 30 degrees. The minimum current is that which causes deflections at an incident angle of 90 degrees with respect to the axis of the coil. The currents in Figure III-2 represent upper and lower limits for creating magnetic fields of the coil.

#### EXAMPLES 3 AND 4

Both Examples 3 and 4 problems compute the magnetic field strengths at any point in space. The Example 3 problem gives the input necessary to obtain from the program these strengths. The order and makeup of a sample problem deck are shown in Figure 7. The first card must have the following information to produce plot information:

1. SMAX is the number of steps to be taken on a trace.
2. HMAX indicates the number of zones in which the coil configuration is divided.
3. MMAX indicates the number of angular increments over which traces will be taken.
4. IMAX indicates the number of current values of which field plots will be made.
5. IAT is a switching signal, which determines whether this problem is a field plot run. IAT = 0 indicates a field plot.
6. JAT greater than 0 will determine the type of printout format. JAT = 2 is used for more than one current value input.
7. LAT = 1 can be used if only 1 value of current is input. For multiple values of current, the value of 2 is assigned to LAT.

In the second card, AGMX, AAAA, BBBB, and MO need not be assigned values other than 0, but if their values are input, the problem will not be affected.

In the third card, DTETAO need not be input but a value in this position will not affect a field plot problem.

1. DTHETA is the angular increment over which a trace is varied.
2. DR represents the incremental step sizes taken along a trace.
3. RMAX represents the greatest distance from the center of the co-ordinate system where DR will begin to be stepped along a trace.

[illegible]

**Figure 7. Order of Example 3 Problem**



Cards 4 to 8 have HMAX values of ZHMAX, ZHMIN, DZH, DA/DZ, AHMAX, and AHMIN, respectively. These cards represent the coil geometry in its entirety.

Immediately following the configuration cards numbered 4 to 8 will be IMAX values of EOT and VOT, respectively, which will be zeros for the field plot problem. If values other than 0 are input, the problem will not be affected. Following values of EOT and VOT will be IMAX values of IOT, the current.

The sample problem printout of Example 3 is shown in Appendix IV. Note that JAT and LAT both have values of 1. It can be seen that one value of current is input in Example 3. In the printout there are six printed columns (Appendix IV) as follows:

1. Theta is the angle in radians over which the magnetic field trace of points was taken. As can be seen at the top of the printout, the increment of change in THETA is DTHETA equal to 15 degrees. The first column reflects this information.

2. Since the problem model exhibits cylindrical symmetry,  $\rho$  represents the radial distance from the coil axis to the point at which the magnetic field is being computed, where

$$\rho = (x^2 + y^2)^{\frac{1}{2}}$$

$$= [R_{max} - (n-1)DR] \sin \theta$$

and

$$n = 1, 2, 3, \dots, k.$$

The program computes this value.

3. The point of magnetic field computation in the Z direction is ZS, where

$$ZS = [R_{max} - (n-1)DR] \cos \theta.$$

The program computes this value.

4. SBN is the absolute value of the magnetic field at the point  $(\rho, ZS)$ ,

$$SBN = (B_{\rho}^2 + B_z^2)^{\frac{1}{2}}$$

where  $B_{\rho}$  and  $B_z$  are defined in the next two columns.

5. SBRHO is the radial component of magnetic field. When  $\rho = 0$ , SBRHO will be equal to 0. SBRHO was defined in Equation (4).

6. The SBZ is the Z component of magnetic field and was defined in Equation (4).

In Example 4, slightly different input values were used and the printout is different from that of Example 3. In the input, IMAX = 12. In this printout, IMAX = 12, which indicates 12 values of EOT, VOT, and IOT, respectively. The EOT does not enter into any

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computations but acts as a means for identifying the derivation of the current IOT. The printout of Example 4 is also shown in Appendix IV.

The currents listed are those which created magnetic fields of sufficient strength about the described coil configuration to cause deflection of charged particles with EOT million electron volts.

Since VOT does not enter into the computation, 12 values of 0 are input. It is essential that these 12 positions be filled.

There are 7 columns in this printout. The added column is the value of IOT. Within each value of IOT, traces over all angles are taken. This type of printout results when the value of 2 is assigned to JAT and LAT. Field plots for all values of IOT were not computed because of the error returned shown at the end of the printout. For example,

VKSQ = 1.000000015 STOP

If, on the trace of the line on which a field plot is being taken, the Z component of coil corresponds to ZS of the reference point and the radius of a zone AHMAX exists so that  $\rho/DR = AHMAX$ , VKSQ is printed out, which indicates an error. This error originates in the elliptic function routine where the elliptic function

$$E(k) \propto \frac{1}{(1 - k^2 \sin^2 \theta)^{\frac{1}{2}}}$$

where

$$k^2 = VKSQ.$$

If  $k^2$  is too close to the value of 1, the program writes out the error statement and stops.

If AHMAX/DR is an integer, an error printout will probably result. For example, as shown at the end of Example 4 of Appendix IV, the value of the ratio  $48/8 = 6$ . The point on which the magnetic field was being computed lay on the periphery of the coil. We recommend that DR and/or RMAX be changed.

The data from the printout of Example 3 as given in Appendix IV is plotted in Figures IV-1 through IV-4. Multiple peaks appear on the 15-degree and 30-degree line traces. The meaning of these multiple peaks is not clear until the equipotential plots are considered. As the line traces approach 90 degrees, single peaks are observed. Figures IV-1 through IV-4 represent the radial component of magnetic field. These graphs are plots of the magnetic field that caused a 500 Mev proton to be deflected.

No plots were made of the magnetic field traces because of low current values, but equipotential lines were plotted in Figures IV-5 and IV-6. Equipotentials of  $B_{\rho}$  and  $B_z$ , respectively, have been plotted. Note that the radial component of magnetic field goes to zero at the ends and is normal to the coil axis at the center of this model. The equipotential of the Z component of magnetic field shown in Figure IV-6 reveals dips at the 45-degree and 135-degree line traces. The critical current versus particle incident angle should have reflected these dips. This information implies that twin peaks should have appeared at the 45-degree and 135-degree angles in Figures II-1 and III-1. Since traces were not taken at these angles, this information was not revealed. The coil could be re-designed to eliminate these dips.

The equipotential of the Z component of magnetic field is shown in Figure IV-7. This equipotential was derived from the current, which caused a 500-Mev particle to be deflected.

At relatively high values of current, the equipotentials appear smooth. The present state of the art leaves considerable doubt as to the ability of superconductors to generate a magnetic field of this strength. Superconductivity is at present in its infancy. High magnetic field breakthroughs are promised in the future for superconductors that can fill the range of fields required by this investigation.

#### RELATIVE ERROR

The technique used in computing a trajectory of a particle is that of defining the new position of a particle with respect to the magnetic field parameters of the last position as follows:

$$x = x_0 + v_x (\Delta t)$$

$$y = y_0 + v_y (\Delta t)$$

$$z = z_0 + v_z (\Delta t)$$

Position co-ordinates x, y, and z are functions of the magnetic field strength at  $x_0$ ,  $y_0$ , and  $z_0$ . The x, y, and z components of velocity are the parameters controlled by the local magnetic field. Obviously, some error is introduced into the program when successive steps are taken into the target area. This occurs when the new position is computed as a function of the local conditions of the last position. As the distance between the particle and the target approach zero, the time steps were made smaller and smaller.

In the computer program the values of  $\Delta t$  are approximately

$$\begin{aligned} \Delta t &= 1.5625 \times 10^{-2} \text{ seconds} \\ &= 1.953125 \times 10^{-3} \text{ seconds} \\ &= 2.4414063 \times 10^{-4} \text{ seconds} \\ &= 3.0517578 \times 10^{-5} \text{ seconds} \\ &= 3.8146973 \times 10^{-6} \text{ seconds} \\ &= 4.7 \times 10^{-7} \text{ seconds} \\ &= 6 \times 10^{-8} \text{ seconds.} \end{aligned}$$

The expression for the position equation is written

$$x = x_0 + v_x (n \Delta t) \tag{10}$$

where n is the number of the step being taken over element of time  $\Delta t$ . Suppose the particle is made to travel from point 1 to point 2 with the largest time step. When the second  $\Delta t$  is used, approximately seven steps would be required to go from point 1 to point 2. In other words, n would vary from 1 to 7 in the preceding equation.

When one large step is taken from point 1 to point 2, the magnetic field at point 1 was assumed to operate on the charged particle over the entire distance. As  $\Delta t$  is made smaller, the number of steps  $n$  from position 1 to position 2 increases. As the number of steps increase, the magnetic field influences to a greater degree the trajectory of the charged particle, that is, the Larmor radius becomes smaller. When the Larmor radius of the charged particle is compared by use of small time steps to the Larmor radius by use of larger time steps, the degree of deviation at point 2 in all cases is negligible. The points 1 and 2 were taken at a large distance from the coil, which may account for the negligible deflection. Previous computer runs indicate significant deflection takes place at 5 to 10 meters from the coil model of this problem. The current in the coil creating the magnetic field is directly proportional to the particle energy. In all cases, significant deflections took place within 5 to 10 meters.

### CONCLUSIONS

From the investigation, it is apparent that shielding from charged particles by means of magnetic fields is possible in outer space. When simulated superconductor coil geometries are used, preliminary investigations indicate logical system parameters.

Superconductor theory is in its infancy. Future investigations promise to advance the technology of superconductivity to the point at which currents and fields as predicted with this program will be possible. More elaborate tools for analyzing coil designs for space shielding purposes will be forthcoming.

## LIST OF REFERENCES

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6. Verga, Robert L. and Cooper Richard F., Weight of Radiation Shielding as a Factor in Designing Propulsion Systems for Manned Space Flights, ASD-TDR-62-697, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, April 1963.
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APPENDIX I

DESCRIPTION OF FORTRAN PROGRAM

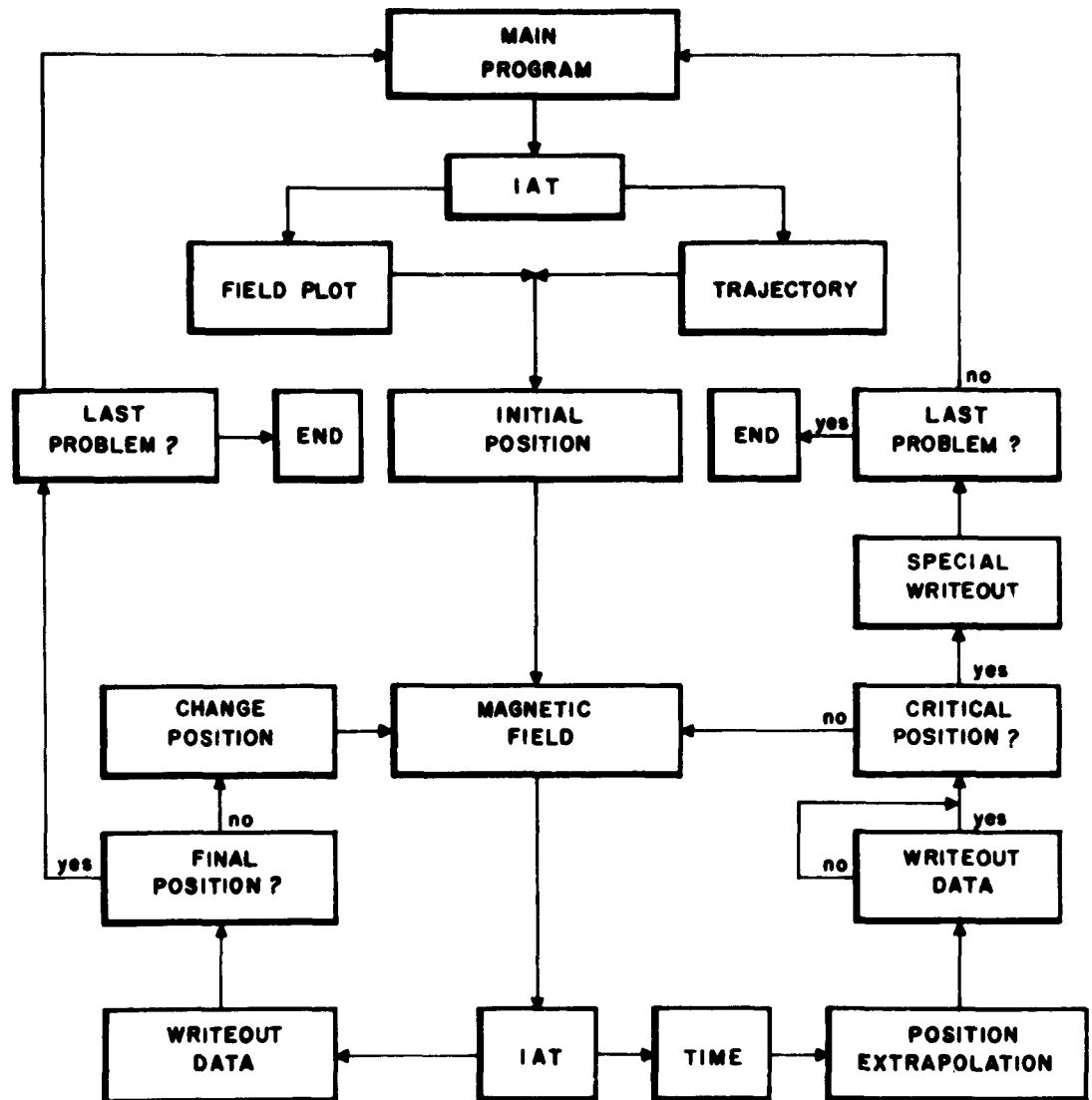


Figure I-1. Composite Flow Diagram of Fortran Program

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The total program is composed of a main program and seven subroutines. The subroutines and their functions are listed as follows:

1. Input

Readin of formats and writeout of input information

2. SUMB

Computing and summing the components of magnetic field

3. SRS

Elliptic function tables

4. MLH

Miss and last hit printout formats

5. TRAJ

Format for printing particle trajectories

6. TIME

Element of time selection routine

7. INTP

New position interpolation routine



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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
*62-038      500      3      O.S.ELMER WHITE
      DIMENSIONTN(9),ZHMAX(50),ZHMIN(50),EOT(200),VOT(200),
      1VOT(200),DZH(50),AHMAX(50),EOT1(200),VOT1(200),VOT1(200),
      2DADDZ(50),AHMIN(50),ALRCOL(50),RE(50),SOL(50),SM(50),
      3UM(50),TM(50),P(50),VOT2(50)
      COMMONZHCIL,AMOM,ACOIL,Z,BRHO,BZ,BN,ISMAX,IHMAX,
      1IMAX,IMAX,IAT,JAT,LAT,AMAX,AMIN,DADDZ,VMO,PHI,
      2THETAO,DTETAO,ZHMAX,ZHMIN,EOT,VCT,VOT,DZH,KAC,IT,T,
      3ZS,RHO,VI,U,N,I,VK,WX,WY,WZ,VX,VY,VZ,DT,VXO,VY0,VZ0,X0,
      4Y0,Z0,X5,Y5,SX5,SY5,SVI,STETAO,SEOT,SVOT,SVIOT,XS,YS,
      5JK,SRS1,SRS2,DTHETA,DR,RMAX,U0,VKSO,SZS,SN,EOT1,VOT1,
      6VOT1,SEOT1,SVOT1,SVIOT1,AGMX,AAA,BBB,KAT,SBZ,SBRHO
      7,IH,SSBN,ARRCOL,SIGC,SIGS,SIGW,BC,DAYS,TM,ITHAT
398  IFP=1
      GOTO404
399  IFPAX=IMAX
      M=1
      IF(IAT)500,400,500
400  IF(LAT-2)402,410,403
402  IF(JAT-2)398,401,500
410  CONTINUE
401  IFP=IFP+1
      IF(IFP-IFPAX)700,700,403
403  CONTINUE
404  CALLEXIT
      CALLINPUT
      CONV=0.02540005
      CONV1=.017453293
499  DO60I=1,IMAX
      EOT1(I)=EOT(I)
      VOT1(I)=VOT(I)
      VOT2(I)=VOT1(I)
60  DO75IH=1,IHMAX
      AHMAX(IH)=CONV*AHMAX(IH)
      AHMIN(IH)=CONV*AHMIN(IH)
      DZH(IH)=CONV*DZH(IH)
      DADDZ(IH)=CONV*DADDZ(IH)
      ZHMIN(IH)=CONV*ZHMIN(IH)
      ZHMAX(IH)=CONV*ZHMAX(IH)
75  DTHETA=CONV1*DTHETA
      DTETAO=CONV1*DTETAO
      RMAX=CONV*RMAX
      DR=CONV*DR
      AGMX=CONV*AGMX
      SIS=1

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500 KAT=0
    IT=1
    UO=1.257E-6
    Q=1.6E-19
    CL=2.998E8
    BN=0.
    M=1
    IH=1
    IS=1
    N=1
505 ISMAX=ISMAX
    IHMAX=IHMAX
    MMAX=MMAX
    IMAX=IMAX
    IAT=IAT
    JAT=JAT
    LAT=LAT
    IF((JAT**2-2)-(LAT**3-2)+(IAT)900,20,21
900 WRITEOUTPUTTAPE3,901
    GOTO700
20 WRITEOUTPUTTAPE3,996
700 IF((JAT-2)800,801,801
800 I=1
    GOTO2
801 I=IFP
2 VM=M-1
    THETA=VM*DTHEA
    A=COSF((VM)*DTHEA)
    B=SINF((VM)*DTHEA)
3 VS=IS-1
    RHO=(RMAX-VS*DR)*B
    ZS=(RMAX-VS*DR)*A
4 CALLSUMB
    IF(ZHCOIL-ZHMAX(IH))5,6,6
5 N=N+1
    GOTO4
6 N=1
    IF(IH-IHMAX)7,8,8
7 IH=IH+1
    N=1
    IF(IAT)700,700,4
8 IH=1
    IF((JAT**2-2)-(LAT**3-2)+(IAT)200,201,23
201 WRITEOUTPUTTAPE3,998,THETA,RHO,ZS,SN,SNRHO,SBZ
    SBZ=0.

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SBN=0.
SBRHO=0.
IF (IS-ISMAX) 9,10,10
200 WRITEOUTPUTAPE3,902,THETA,RHO,ZS,SBN,VLOT(1),SBRHO,SBZ
    SBZ=0
SBN=0
SBRHO=0
IF (IS-ISMAX) 9,10,10
9   IS=IS+1
    GOTO3
10  IF (M-MMAX) 11,399,403
11  M=M+1
    IS=1
    IH=1
    GOTO2
996 FORMAT(9H THETA ,11X,4HRHO,17X,2HZS,19X,3HSBN,16X,5HSBRHO,
120X,3HSBZ)
998 FORMAT(F9.4,1P5E20.8)
901 FORMAT(9H THETA ,5X,4HRHO ,8X,2HZS,8X,3HSBN,
19X,5H IOT ,4X,5HSBRHO,6X,3HSBZ)
902 FORMAT(F9.4,1P9E11.4)
21  IF (I-1) 211,51,51
211 I=1
51  VM2=1.- (VOT(1)/CL)**2
    VM1=VM0/SQRTF(VM2)
    KAC=0
    IT=1
    T=0
    DT=0
    IH=1
    IF (I-IMAX) 24,24,30
25  IF (SIS) 502,502,24
502 IF (DTETAO) 26,27,26
26  J=J+1
    VJ=J
    THETA0=VJ*DTETAO
    PHI=0
    SIS=1
    SRA=0
    IF (THETA0-3.14159000) 500,500,27
27  IF (LAT) 29,29,30
29  CALLMIH
    THETA0=0
    J=0
    SRA=0

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I=I+1
IF(I-IMAX)500,500,30
GOTO403
VX0=-(VOT(I))*(SINF(THETA0))*COSF(PHI)
VY0=(VOT(I))*(SINF(THETA0))*SINF(PHI)
VZ0=-(VOT(I))*(COSF(THETA0))
VX=VX0
VY=VY0
VZ=VZ0
ST=.12499999
X0=-ST*VX0
Y0=ST*VY0
Z0=-ST*VZ0
XS=X0
YS=Y0
ZS=Z0
R=SQRTF(XS**2+YS**2+ZS**2)
RHO =SQRTF(XS**2+YS**2)
IF(R-AGMX)597,597,33
33 IF(KAT)74,74,34
74 KAT=1
34 GOTO4
CALLINTP
KAT=0
GOTO31
597 IHR=IH
KAT=0
32 IF(ZS-ZHMIN(IH))35,36,36
36 IF(ZS-ZHMAX(IH))37,37,35
35 IF(IH-IHMAX)600,598,598
600 IH=IH+1
IF(IH-IHR)32,38,32
598 IH=1
599 IF(IH-IHR)32,38,38
38 IH=IHR
39 TOL=T-.12499999
IH=1
IF(TOL-1E-08)33,33,139
139 SIS=0
GOTO57
37 IF(RHO-AHMAX(IH))42,42,33
42 IF(DADDZ(IH))46,46,47
46 AHOM=AHMAX(IH)
GOTO48
47 AHOM=AHMIN(IH)

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48      AHCOIL=(ZS-ZHMIN(IH))*DADDZ(IH)*AMOM
      IF(RHO-AHCOIL)49,49,39
      STORE HIT
49      RA=SQRT(IX**2+YS**2+ZS**2)
493     ITHAT=ITHAT+1
      IF(ITHAT-1)507,507,506
506     SIS=0
507     IF(JAT)510,510,509
510     CALLTRAJ
509     DT=0
      KAC=0
      IT=1
      T=0
      IF((RA-SRA)-.000001)501,491,491
501     IF(ITHAT-1)491,491,490
490     ITHAT=0
      CALLMLH
      VIOT(I)=VIOT2(I)
      GOTO25
491     SXS=XS
      SYS=YS
      SZS=ZS
      SSBN=SBN
      SVIOT=VIOT(I)
      STETAO=THETAO
      SEOT1=EOT1(I)
      SVOT1=VOT1(I)
      SVIOT1=VIOT1(I)
      SRA=SQRT(IXS**2+SYS**2+SZS**2)
      VIOT(I)=AAAA*VIOT(I)+8888
      IH=1
      N=1
      PHI=0
      SIS=0
      KAT=0
      GOTO24
23     IF(JAT)52,52,53
52     CALLTRAJ
53     IH=1
      N=1
      CALLTIME
      IT=IT
      T=T
      KAC=KAC
      IF(IT-9)54,54,55

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57 IF(JAT)56,56,55
58 CALLTRAJ
59 CALLMLH
55 VIOT(I)=VIOT2(I)
   KAT=0
   SBZ=0
   SBRHO=0
   SBN=0
555 IF(THETA0-3.14159000)502,556,556
556 I=I+1
   THETA0=0
   J=0
   SRA=0
   IF(I-IMAX)500,500,30
   BX=SBRHO*COSF(PHI)
   BY=SBRHO*SINF(PHI)
   WX=Q/VM1*BX
   WY=Q/VM1*BY
   WZ=Q/VM1*SBZ
   SBZ=0.
   SBRHO=0.
   SBN=0
   GOTO34
   END
   SUBROUTINEINPUT
   DIMENSIONX(220)
   DIMENSIONY(220)
   DIMENSIONTN(9),ZHMAX(50),ZHMIN(50),EOT(200),VOT(200),
1VIOT(200),DZH(50),AHMAX(50),EOT1(200),VOT1(200),VIOT1(200),
2DADDZ(50),AHMIN(50),ALRCOL(50),RE(50),SOL(50),SM(50),
3UM(50),TM(50),P(50)
   COMMONZHCIL,AMOM,ACOIL,2,BRHO,BZ,BN,ISM,ISMAX,IHMAX,
   IMMAX,IMAX,IAT,JAT,LAT,AHMAX,AHMIN,DADDZ,VMO,PHI,
   2THETA0,DTETA0,ZHMAX,ZHMIN,EOT,VOT,VIOT,DZH,KAC,IT,T,
   3ZS,RHO,VI,UN,I,VK,WX,WY,WZ,VX,VY,VZ,DT,VX0,VY0,VZ0,X0,
   4Y0,Z0,X5,Y5,SXS,SYS,SVI,STETA0,SEOT,SVOT,SVIOT,XS,YS,
   5JK,SRS1,SRS2,DTHEA,DR,RMAX,UO,VKSO,SZS,SBN,EOT1,VOT1,
   6VIOT1,SEOT1,SVOT1,SVIOT1,AGMX,AAAA,B88B,KAT,SBZ,SBRHO
   7,IH,SSBN,ARRCOL,SIGC,SIGS,SIGW,BC,DAYS,TM,I,THAT
   READINPUTTAPE2,995,ISM,ISMAX,IHMAX,IMAX,IAT
   1,JAT,LAT
   READINPUTTAPE2,999,AGMX,AAAA,B88B,VMO,
   1DTETA0,DTHEA,DR,RMAX,
   2(ZHMAX(IH),IH=1,IHMAX), (ZHMIN(IH),IH=1,IHMAX),
   3(DZH(IH),IH=1,IHMAX), (DADDZ(IH),IH=1,IHMAX),

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271 4(AHMAX(IH),IH=1,IHMAX),(AHMIN(IH),IH=1,IHMAX),
272 5(EOT(I),I=1,IHMAX),(VOT(I),I=1,IHMAX),(VIOT(I),I=1,IHMAX)
273 WRITEOUTPUTTAPE3,997
274 WRITEOUTPUTTAPE3,994,ISMAX,IHMAX,MHMAX,IHMAX,IAT,
275 1JAT,LAT,
276 2AGMX,AAAA,888B,VMO,
277 3DTETAO,DTETA,DR,RMAX
278 WRITEOUTPUTTAPE3,993,(ZHMAX(IH),IH=1,IHMAX)
279 WRITEOUTPUTTAPE3,992,(ZHMN(IH),IH=1,IHMAX)
280 WRITEOUTPUTTAPE3,991,(DZH(IH),IH=1,IHMAX)
281 WRITEOUTPUTTAPE3,990,(DADDZ(IH),IH=1,IHMAX)
282 WRITEOUTPUTTAPE3,989,(AHMAX(IH),IH=1,IHMAX)
283 WRITEOUTPUTTAPE3,988,(AHMIN(IH),IH=1,IHMAX)
284 WRITEOUTPUTTAPE3,987,(EOT(I),I=1,IHMAX)
285 WRITEOUTPUTTAPE3,986,(VOT(I),I=1,IHMAX)
286 WRITEOUTPUTTAPE3,985,(VIOT(I),I=1,IHMAX)
287 FORMAT(6H SMAX=13.8H MHMAX=13.8H MHMAX=13,
288 18H IMAX=13.7H IAT=13.7H JAT=13.7H LAT=13/
289 26H AGMX=1PE13.7,8H AAAA=1PE13.7,8H 888B=1PE13.7,
290 36H MO=1PE13.7,10H DTETAO=1PE13.7,10H DTETA=1PE13.7,
291 46H DR=1PE13.7,8H RMAX=1PE13.7)
292
293 FORMAT(7H ZHMAX=1P5E18.7)
294
295 FORMAT(7H ZHMN=1P5E18.7)
296
297 FORMAT(5H DZH=1P5E18.7)
298
299 FORMAT(7H DA/DZ=1P5E18.7)
300
301 FORMAT(7H AHMAX=1P5E18.7)
302
303 FORMAT(7H AHMIN=1P5E18.7)
304
305 FORMAT(5H EOT=1P9E11.4)
306
307 FORMAT(5H VOT=1P9E11.4)
308
309 FORMAT(5H IOT=1P9E11.4)
310
311 FORMAT(27H CHARGED PARTICLE SHIELDING
312 1/29H IAT=0 INDICATES A FIELD PLOT
313 2/29H IAT=1 INDICATES A TRAJECTORY
314 3/37H JAT=0 INDICATES A PLOT OF TRAJECTORY
315 4/36H JAT=1 INDICATES NO PLOT OF TRAJECTORY
316 5/36H JAT=2 INDICATES MULTIPLE CURNT VALUES
317 6/39H LAT=0 INDICATES DUMP MISS AND LAST HIT
318 7/42H LAT=1 INDICATES NO DUMP MISS AND LAST HIT
319 8/30H LAT=2 MULTIPLE CURNT FIELD PLOT)
320
321 FORMAT(4E13.7)
322
323 FORMAT(6X24I3)
324
325 RETURN
326
327 END
328
329 SUBROUTINESUMB
330 DIMENSIONNTN(9),ZHMAX(50),ZHMN(50),EOT(200),VOT(200),

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1 VIOT(200),DZH(50),AHMAX(50),EOT1(200),VOT1(200),VOT1(200),VOT1(200),
2 DADDZ(50),AHMIN(50)
3 COMMONZHCIL,AMOM,ACOIL,Z,BRHO,BZ,BN,ISMAX,IHMAX,
4 IMAX,IMAX,IAT,JAT,LAT,AHMAX,AHMIN,DADDZ,VMO,PHI,
5 2THETAO,DTETAO,ZHMAX,ZHMIN,EOT,VOT,VOT,DZH,KAC,IT,T,
6 3ZS,RHO,VI,U,N,I,VK,WX,WY,WZ,VX,VY,VZ,DT,VXO,VYO,VZO,XO,
7 4Y0,Z0,X5,Y5,SXS,SYS,SVI,STETAO,SEOT,SVOT,SVIOT,XS,YS,
8 5JK,SRS1,SRS2,DTHETA,DR,RMAX,UO,VKSQ,SZS,SBN,EOT1,VOT1,
9 6VOT1,SEOT1,SVOT1,SVIOT1,AGMX,AAAA,BBBB,KAT,SBZ,SBRHO
10 7,IH,SSBN,ARRCOL,SIGC,SIGS,SIGW,BC,DAYS,TM,ITHAT
11 VN=N-1
12 ZHCIL=ZHMIN(IH)+VN*DZH(IH)
13 IF(DADDZ(IH))2,2,1
14 AMOM=AHMIN(IH)
15 GOTO3
16 AMOM=AHMAX(IH)
17 ACOIL=DADDZ(IH)*VN+AMOM
18 Z=ZS-ZHCIL
19 VKSQ= ((14.*RHO*ACOIL)/((RHO+ACOIL)**2+Z**2))
20 CALLSRS
21 C=((UO*VIOT(1))/6.28318531)/SQRTF((RHO+ACOIL)**2+Z**2)
22 IF(RHO)4,5,4
23 BRHO=0
24 GOTO6
25 BRHO=(C*Z/RHO)*(-SRS1 +((ACOIL**2+RHO**2+Z**2)/
26 1((ACOIL-RHO)**2+Z**2))*SRS2)
27 BZ=C*(-SRS1 +((ACOIL**2-RHO**2-Z**2)/
28 1((ACOIL-RHO)**2+Z**2))*SRS2)
29 BN=SQRTF(BRHO**2+BZ**2)
30 SBRHO=SBRHO+BRHO
31 SBZ=SBZ+BZ
32 SBN=SBN+BN
33 RETURN
34 FORMAT(3H K=1PE15.7)
35 999
36 END
37 SUBROUTINEINTP
38 DIMENSIONTN(9),ZHMAX(50),ZHMIN(50),EOT(200),VOT(200),
39 1VIOT(200),DZH(50),AHMAX(50),EOT1(200),VOT1(200),VOT1(200),
40 2DADDZ(50),AHMIN(50)
41 COMMONZHCIL,AMOM,ACOIL,Z,BRHO,BZ,BN,ISMAX,IHMAX,
42 IMAX,IMAX,IAT,JAT,LAT,AHMAX,AHMIN,DADDZ,VMO,PHI,
43 2THETAO,DTETAO,ZHMAX,ZHMIN,EOT,VOT,VOT,DZH,KAC,IT,T,
44 3ZS,RHO,VI,U,N,I,VK,WX,WY,WZ,VX,VY,VZ,DT,VXO,VYO,VZO,XO,
45 4Y0,Z0,X5,Y5,SXS,SYS,SVI,STETAO,SEOT,SVOT,SVIOT,XS,YS,
46 5JK,SRS1,SRS2,DTHETA,DR,RMAX,UO,VKSQ,SZS,SBN,EOT1,VOT1,

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361 6VIOT1,SEOT1,SVOT1,SVIOT1,AGMX,AAAA,BBBB,KAT,SBZ,SBRHO
362 7,IH,SSBN,ARRCOL,SIGC,SIGS,SIGW,BC,DAYS,TM,I THAT
363 DVXDDT=WZ*VY-WY*VZ
364 DVYDDT=WX*VZ-WZ*VX
365 DVZDDT=WY*VX-WX*VY
366 VX=DVXDDT*DT+VX0
367 VY=DVYDDT*DT+VY0
368 VZ=DVZDDT*DT+VZ0
369 XSS=X0
370 YSS=Y0
371 ZSS=Z0
372 XS=X0+VX*DT
373 YS=Y0+VY*DT
374 ZS=Z0+VZ*DT
375 X0=XS
376 Y0=YS
377 Z0=ZS
378 VX0=VX
379 VY0=VY
380 VZ0=VZ
381 IF(ABSF(XSS-XS)+ABSF(YSS-YS))10,11,10
382 IF(XSS-XS)1,2,1
383 PHI=ATANF((YSS-YS)/(XSS-XS))
384 GOTO3
385 PHI=90.*.01745329252
386 GOTO3
387 PHI=0.
388 IF(I THAT-1)3,12,12
389 PHI=5.*.01745329252
390 KAT=0
391 RETURN
392 END
393 SUBROUTINE TIME
394 DIMENSION TN(9),ZHMAX(50),ZHMIN(50),EOT(200),VOT(200),
395 1VIOT(200),DZH(50),AHMAX(50),EOT1(200),VOT1(200),
396 2DADDZ(50),AHMIN(50)
397 COMMON ZHCOIL,AMOM,ACOIL,Z,BRHO,BZ,BN,ISMAX,IHMAX,
398 1IMAX,IMAX,IAT,JAT,LAT,AHMAX,AHMIN,DADDZ,VM0,PHI,
399 2THETA0,DTETA0,ZHMAX,ZHMIN,EOT,VOT,VIOT,DZH,KAC,IT,T,
400 3ZS,RHO,VI,U,N,I,VK,WX,WY,WZ,VX,VY,VZ,DT,VX0,VY0,VZ0,X0,
401 4Y0,Z0,X5,Y5,SXS,SYS,SVI,STETA0,SEOT,SVOT,SVIOT,XS,YS,
402 5JK,SRS1,SRS2,DTHETA,DR,RMAX,U0,VKSO,SZS,SRN,EOT1,VOT1,
403 6VIOT1,SEOT1,SVOT1,SVIOT1,AGMX,AAAA,BBBB,KAT,SBZ,SBRHO
404 7,IH,SSBN,ARRCOL,SIGC,SIGS,SIGW,BC,DAYS,TM,I THAT
405 TN(1)=173400000000

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      8      TN(2)=1704000000000
      8      TN(3)=1654000000000
      8      TN(4)=1624000000000
      8      TN(5)=1574000000000
      8      TN(6)=1544000000000
      8      TN(7)=1514000000000
      8      TN(8)=1464000000000
      8      TN(9)=1464000000000
      8      DT=TN(IT)
      8      T=T+DT
      8      KAC=KAC+1
      8      IF(KAC-7)1,2,2
      1      RETURN
      2      IT=IT+1
      8      KAC=0
      8      RETURN
      8      END
      8      SUBROUTINE SRS
      8      DIMENSION X(220)
      8      DIMENSION Y(220)
      8      DIMENSION TN(9), ZHMAX(50), ZHMIN(50), EOT(200), VOT(200),
      8      1 VOT(200), DZH(50), AHMAX(50), EOT1(200), VOT1(200), VOTI1(200),
      8      2 DADDZ(50), AHMIN(50)
      8      COMMON ZHCOIL, AMOM, ACOIL, Z, BRHO, BZ, BN, ISMAX, IHMAX,
      8      1 IMAX, IMAX, IAT, JAT, LAT, AHMAX, AHMIN, DADDZ, VMO, PHI,
      8      2 THETA0, DTETA0, ZHMAX, ZHMIN, EOT, VOT, VOT, DZH, KAC, IT, T,
      8      3 ZSRHO, VI, U, N, I, VK, WX, WY, WZ, VX, VY, VZ, DT, VX0, VY0, VZ0, X0,
      8      4 Y0, Z0, X5, Y5, XS, SYS, SVI, STETA0, SEOT, SVOT, SVIOT, XS, YS,
      8      5 JK, SRS1, SRS2, DTHETA, DR, RMAX, UO, VKSQ, SZS, SBN, EOT1, VOT1,
      8      6 VOTI1, SEOT1, SVOT1, SVIOT1, AGMX, AAA, BBBB, KAT, SBZ, SBRHO
      8      7, IH, SBN, ARCOL, SIGC, SIGS, SIGW, BC, DAYS, TM, ITHAT
      8      IF(VKSQ-.9999999)21,21,11
      8      WRITE(OUTPUTTAPE3,999,VKSQ)
      8      CALLEXIT
      8      11 IF(VKSQ-.961)31,41,41
      8      21 IF(VKSQ-.961)31,41,41
      8      31 SRS1=1.57079633
      8      SRS2=1.57079633
      8      Z1=0.
      8      Z2=0.
      8      AAA1=1.
      8      AAA2=1.
      8      ME=2
      8      VME=ME
      8      91 AA1=((2.*(VME-1.))-1.)/(2.*(VME-1.))**2*AAA1
      8      AA2=AA1/(2.*VME-3.)

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AAA1=AA1
AA2=AA2
Z1=1.57079633*AA1*VKSQ**(ME-1)
Z2=1.57079633*AA2*VKSQ**(ME-1)
IF(Z1/SRS1-5.E-10)61,61,71
SRS1=SRS1+Z1
SRS2=SRS2-Z2
ME=ME+1
GOTO51
RETURN
CONTINUE
Y(1)=3.0284
Y(2)=3.0539
Y(3)=3.0809
Y(4)=3.1095
Y(5)=3.1399
Y(6)=3.1724
Y(7)=3.2073
Y(8)=3.2449
Y(9)=3.2857
Y(10)=3.3302
Y(11)=3.3793
Y(12)=3.4340
Y(13)=3.4955
Y(14)=3.5661
Y(15)=3.6485
Y(16)=3.7478
Y(17)=3.8723
Y(18)=4.0393
Y(19)=4.2933
Y(20)=4.2950
Y(21)=4.2983
Y(22)=4.3017
Y(23)=4.3051
Y(24)=4.3085
Y(25)=4.3119
Y(26)=4.3154
Y(27)=4.3189
Y(28)=4.3224
Y(29)=4.3259
Y(30)=4.3295
Y(31)=4.3331
Y(32)=4.3367
Y(33)=4.3403
Y(34)=4.3440

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Y(35)=4.3447	496
Y(36)=4.3514	497
Y(37)=4.3551	498
Y(38)=4.3589	499
Y(39)=4.3627	500
Y(40)=4.3665	501
Y(41)=4.3704	502
Y(42)=4.3743	503
Y(43)=4.3782	504
Y(44)=4.3822	505
Y(45)=4.3861	506
Y(46)=4.3902	507
Y(47)=4.3942	508
Y(48)=4.3983	509
Y(49)=4.4024	510
Y(50)=4.4066	511
Y(51)=4.4107	512
Y(52)=4.4150	513
Y(53)=4.4192	514
Y(54)=4.4235	515
Y(55)=4.4279	516
Y(56)=4.4322	517
Y(57)=4.4366	518
Y(58)=4.4411	519
Y(59)=4.4456	520
Y(60)=4.4501	521
Y(61)=4.4547	522
Y(62)=4.4593	523
Y(63)=4.4640	524
Y(64)=4.4687	525
Y(65)=4.4734	526
Y(66)=4.4792	527
Y(67)=4.4830	528
Y(68)=4.4879	529
Y(69)=4.4929	530
Y(70)=4.4978	531
Y(71)=4.5029	532
Y(72)=4.5080	533
Y(73)=4.5131	534
Y(74)=4.5183	535
Y(75)=4.5235	536
Y(76)=4.5289	537
Y(77)=4.5342	538
Y(78)=4.5396	539
Y(79)=4.5451	540

Y(80)=4.5507	541
Y(81)=4.5563	542
Y(82)=4.5619	543
Y(83)=4.5677	544
Y(84)=4.5735	545
Y(85)=4.5793	546
Y(86)=4.5853	547
Y(87)=4.5913	548
Y(88)=4.5973	549
Y(89)=4.6035	550
Y(90)=4.6097	551
Y(91)=4.6161	552
Y(92)=4.6224	553
Y(93)=4.6289	554
Y(94)=4.6355	555
Y(95)=4.6421	556
Y(96)=4.6489	557
Y(97)=4.6557	558
Y(98)=4.6626	559
Y(99)=4.6697	560
Y(100)=4.6768	561
Y(101)=4.6840	562
Y(102)=4.6914	563
Y(103)=4.6988	564
Y(104)=4.6064	565
Y(105)=4.7140	566
Y(106)=4.7218	567
Y(107)=4.7298	568
Y(108)=4.7378	569
Y(109)=4.7460	570
Y(110)=4.7543	571
Y(111)=4.7628	572
Y(112)=4.7714	573
Y(113)=4.7801	574
Y(114)=4.7890	575
Y(115)=4.7981	576
Y(116)=4.8074	577
Y(117)=4.8168	578
Y(118)=4.8264	579
Y(119)=4.8362	580
Y(120)=4.8461	581
Y(121)=4.8563	582
Y(122)=4.8667	583
Y(123)=4.8774	584
Y(124)=4.8882	585

Y(125)=4.8993  
 Y(126)=4.9107  
 Y(127)=4.9223  
 Y(128)=4.9342  
 Y(129)=4.9463  
 Y(130)=4.9588  
 Y(131)=4.9716  
 Y(132)=4.9848  
 Y(133)=4.9983  
 Y(134)=5.0121  
 Y(135)=5.0264  
 Y(136)=5.0411  
 Y(137)=5.0562  
 Y(138)=5.0718  
 Y(139)=5.0879  
 Y(140)=5.1046  
 Y(141)=5.1218  
 Y(142)=5.1397  
 Y(143)=5.1582  
 Y(144)=5.1774  
 Y(145)=5.1974  
 Y(146)=5.2182  
 Y(147)=5.2399  
 Y(148)=5.2626  
 Y(149)=5.2864  
 Y(150)=5.3114  
 Y(151)=5.3377  
 Y(152)=5.3655  
 Y(153)=5.3949  
 Y(154)=5.4261  
 Y(155)=5.4594  
 Y(156)=5.4951  
 Y(157)=5.5336  
 Y(158)=5.5753  
 Y(159)=5.6207  
 Y(160)=5.6708  
 Y(161)=5.7264  
 Y(162)=5.7889  
 Y(163)=5.8604  
 Y(164)=5.9439  
 Y(165)=6.0443  
 Y(166)=6.1699  
 Y(167)=6.3381  
 Y(168)=6.5935  
 Y(169)=7.1428  
  
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Y(170)=7.1529  
Y(171)=7.1632  
Y(172)=7.1737  
Y(173)=7.1845  
Y(174)=7.1955  
Y(175)=7.2067  
Y(176)=7.2182  
Y(177)=7.2299  
Y(178)=7.2420  
Y(179)=7.2543  
Y(180)=7.2670  
Y(181)=7.2800  
Y(182)=7.2933  
Y(183)=7.3070  
Y(184)=7.3211  
Y(185)=7.3356  
Y(186)=7.3505  
Y(187)=7.3659  
Y(188)=7.3818  
Y(189)=7.3982  
Y(190)=7.4151  
Y(191)=7.4327  
Y(192)=7.4509  
Y(193)=7.4697  
Y(194)=7.4893  
Y(195)=7.5097  
Y(196)=7.5310  
Y(197)=7.5533  
Y(198)=7.5765  
Y(199)=7.6009  
Y(200)=7.6266  
Y(201)=7.6536  
Y(202)=7.6822  
Y(203)=7.7125  
Y(204)=7.7447  
Y(205)=7.7792  
Y(206)=7.8163  
Y(207)=7.8563  
Y(208)=7.8998  
Y(209)=7.9475  
Y(210)=8.0002  
Y(211)=8.0591  
Y(212)=8.1258  
Y(213)=8.2029  
Y(214)=8.2941

Y(215)=8.4056	676
Y(216)=8.5495	677
Y(217)=8.7522	678
Y(218)=9.0988	679
Y(219)=9.4453	680
X(1)=.961	681
DO11=2.19	682
X(1)=X(I-1)+.002	683
X(20)=.99701	684
DO21=21.169	685
X(1)=X(I-1)+.00002	686
X(170)=.9999902	687
X(171)=.9999904	688
X(172)=.9999906	689
X(173)=.9999908	690
X(174)=.9999910	691
X(175)=.9999912	692
X(176)=.9999914	693
X(177)=.9999916	694
X(178)=.9999918	695
X(179)=.9999920	696
X(180)=.9999922	697
X(181)=.9999924	698
X(182)=.9999926	699
X(183)=.9999928	700
X(184)=.9999930	701
X(185)=.9999932	702
X(186)=.9999934	703
X(187)=.9999936	704
X(188)=.9999938	705
X(189)=.9999940	706
X(190)=.9999942	707
X(191)=.9999944	708
X(192)=.9999946	709
X(193)=.9999948	710
X(194)=.9999950	711
X(195)=.9999952	712
X(196)=.9999954	713
X(197)=.9999956	714
X(198)=.9999958	715
X(199)=.9999960	716
X(200)=.9999962	717
X(201)=.9999964	718
X(202)=.9999966	719
X(203)=.9999968	720



X(204)=.9999970  
X(205)=.9999972  
X(206)=.9999974  
X(207)=.9999976  
X(208)=.9999978  
X(209)=.9999980  
X(210)=.9999982  
X(211)=.9999984  
X(212)=.9999986  
X(213)=.9999988  
X(214)=.9999990  
X(215)=.9999992  
X(216)=.9999994  
X(217)=.9999996  
X(218)=.9999998  
X(219)=.9999999  
NUTS=219  
KITS=3  
CALLAITKEN(X,Y,NUTS,KITS,VKSO,SRS1)  
Y(1)=1.04948  
Y(2)=1.04844  
Y(3)=1.04740  
Y(4)=1.04636  
Y(5)=1.04531  
Y(6)=1.04425  
Y(7)=1.04318  
Y(8)=1.04211  
Y(9)=1.04103  
Y(10)=1.03995  
Y(11)=1.03885  
Y(12)=1.03775  
Y(13)=1.03664  
Y(14)=1.03552  
Y(15)=1.03439  
Y(16)=1.03325  
Y(17)=1.03210  
Y(18)=1.03094  
Y(19)=1.02978  
Y(20)=1.02859  
Y(21)=1.02740  
Y(22)=1.02620  
Y(23)=1.02498  
Y(24)=1.02375  
Y(25)=1.02250  
Y(26)=1.02123

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766 Y(27)=1.01995
767 Y(28)=1.01865
768 Y(29)=1.01734
769 Y(30)=1.01599
770 Y(31)=1.01463
771 Y(32)=1.01323
772 Y(33)=1.01181
773 Y(34)=1.01035
774 Y(35)=1.00885
775 Y(36)=1.00730
776 Y(37)=1.00569
777 Y(38)=1.00400
778 Y(39)=1.00217
779 Y(40)=1.00000
780 X(1)=.961
781 DO521=2.40
782 X(1)=X(1-1)+.001
783 NUTS=40
784 KITS=3
785 CALLAITKENIX,Y,NUTS,KITS,VKSQ,SRS2)
786 RETURN
787
788 999 FORMAT(6H VKSQ=F13.9,5H STOP)
789 END
790 SUBROUTINETRAJ
791 DIMENSIONTN(9),ZHMAX(50),ZHMIN(50),EOT(200),VOT(200),
792 1VLOT(200),DZH(50),AHMAX(50),EOT1(200),VOT1(200),
793 2DADDZ(50),AHMIN(50)
794 COMMONZHC0IL,AMOM,ACOIL,Z,BRHO,BZ,BN,ISMAX,IHMAX,
795 1IMAX,IMAX,IAT,JAT,LAT,AHMAX,AHMIN,DADDZ,VMO,PHI,
796 2THETAO,DTETAO,ZHMAX,ZHMIN,EOT,VOT,VLOT,DZH,KAC,IT,T,
797 3ZS,RHO,V1,U,N,I,VK,WX,WY,WZ,VX,VY,VZ,DT,VX0,VY0,VZ0,X0,
798 4Y0,Z0,X5,Y5,SXS,SYS,SVI,STETAO,SEOT,SVOT,XS,YS,
799 5JK,SRS1,SRS2,DTHETA,DR,RMAX,UO,VKSQ,SZS,SBN,EOT1,VOT1,
800 6VLOT1,SEOT1,SVOT1,SVIOT1,AGMX,AAAA,8BBB,KAT,5BZ,5BRHO
801 7,IH,SSBN,ARRCOL,SIGC,SIGS,SIGW,BC,DAYS,TM,ITHAT
802 WRITEOUTPUTTAPE3,999,T,XS,YS,ZS,SBN,THETAO,VLOT(1)
803 FORMAT(3H T=F10.8,6H XS=1PE15.8,6H YS=1PE15.8,
804 25H ZS=1PE15.8/13X6H SBN=1PE15.8,9H THETAO=1PE15.8,
805 25H I=1PE15.8)
806 RETURN
807 END
808 SUBROUTINEMLH
809 DIMENSIONTN(9),ZHMAX(50),ZHMIN(50),EOT(200),VOT(200),
810 1VLOT(200),DZH(50),AHMAX(50),EOT1(200),VOT1(200),
811 2DADDZ(50),AHMIN(50)

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COMMONZHC0IL,ANOM,ACOIL,Z,BRHO,BZ,BN,ISMAX,IHMAX,
1IMAX,IMAX,IAT,JAT,LAT,AHMAX,AHMIN,DADDZ,VMO,PHI,
2THETA0,DTETA0,ZHMAX,ZHMIN,EOT,VOT,VLOT,DZH,KAC,IT,T,
3ZS,RHO,VI,U,N,I,VK,WX,WY,WZ,VX,VY,VZ,DT,VX0,VY0,VZ0,X0,
4Y0,Z0,X5,Y5,SXS,SYS,SVI,STETA0,SEOT,SVOT,XS,YS,
5JK,SRS1,SRS2,DTHETA,DR,RMAX,UO,VKSQ,SZS,SN,EOT1,VOT1,
6VLOT1,SEOT1,SVOT1,SVLOT1,AGMX,AAAA,BBBB,KAT,SBZ,SBRHO
7,IH,SSBN,ARRCOL,SIGC,SIGS,SIGW,BC,DAYS,TM,ITHAT
WRITEOUTPUTTAPE3,999,XS,YS,ZS,VLOT(I),THETA0,EOT1(I),VOT1(I),
1VLOT1(I),SN,SXS,SYS,SZS,SVLOT,STETA0,SEOT1,SVOT1,SSBN
999 FORMAT(5H MISS,4X6H XS=1PE15.8,5H YS=1PE15.8,
15H ZS=1PE15.8,4H I=1PE15.8/9H THETA0=1PE15.8,
26H EOT=1PE15.8,6H VOT=1PE15.8,6H IOT=1PE15.8,6H SN=1PE15.8/
39H LAST HIT,6H XS=1PE15.8,5H YS=1PE15.8,
45H ZS=1PE15.8,4H I=1PE15.8/9H THETA0=1PE15.8,
56H EOT=1PE15.8,6H VOT=1PE15.8,6H IOT=1PE15.8,6H SN=1PE15.8)
RETURN
END

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## ASD-TDR-63-72

The control statements of the main program and their addresses are listed. Explanations of the control statements are provided to allow changes in the main program logic, if this becomes necessary. If changes are made in the main program, a careful check should be made of the subroutine input to see if it is affected.

398     Start.  
404     Call input subroutine.  
499     Allot storage space for the energy, velocity, and current.  
60     Allot storage space for the geometry.  
75     Convert from inches to meters.  
1     If the value of the equation of signals is negative, go to 900 to  
      compute the field plot.  
      If it is zero, go to 20 to compute the field plot.  
      If it is positive, go to 21 to make trajectory computations.

### FIELD PLOT

900     Write out according to format 901.  
20     Write out according to format 996.  
700     If JAT is negative, go to 2.  
      If it is 0 or positive, go to 801.  
801     Use a new subscript.  
2     Compute angular parameters.  
3     Compute cylindrical space coordinates.  
4     Call SUMB, the magnetic field subroutine.  
      Check this zone; if more coil loops are to be computed, go to 5.  
      If this is the last coil loop, go to 6.  
5     Increase the coil index and then go to 4.  
6     If this is not the last zone, go to 7.  
      If this is the last zone, go to 8.  
      If this is a trajectory, go to 4.  
8     If the computed value is negative (-), write out the information  
      requested at 200.  
      If it is 0, write out the information requested at 201.  
      If it is positive, go to 23.  
200     If more coordinates are to be computed, go to 9.  
      If the last coordinates are computed, go to 10.  
201     If more coordinates are to be computed, go to 9.  
      If the last coordinate has been computed, go to 10.

- 9 Step to the next coordinate position and then go to 3.
- 10 If all angles have not been computed, go to 11.  
If all angles have been computed, go to 399 or 403.
- 11 Increase the angle indexing factor, then go to 2.

#### TRAJECTORY

- 21 Check the value of the subscript, then go to 51.
- 51 Compute the relativity mass.  
If the subscript is not a maximum, go to 24.  
If it is a maximum, go to 30.
- 24 Compute the components of velocity and initiate a position of the particle.
- 31 If the position of the particle is outside of the coil configuration, go to 33.  
If the position is inside the coil, go to 597.
- 33 If KAT = 0, the magnetic field has not been computed; go to 74 and then to 4.  
If KAT = 1, the field has been computed. Go to 34.
- 34 Call Subroutine Intp (interpolate).  
Compute the new position of the particle based on local magnetic field conditions. Go to 31.
- 597 Continue.
- 32 If the Z component of the particle is greater than or equal to the minimum Z component of the zone now being checked, go to 36.  
If the Z component of the particle is less than the minimum Z component of the zone being checked, go to 35.
- 35 If this zone is not the last zone, go to 600.  
Go to 598 if this is the last zone.
- 600 Increase the zone subscript.  
Go to 32 to determine if the particle is in the new zone.  
If all zones have been checked and the particle is in none, go to 38.
- 598 Check to see if the particle is in the first zone.
- 599 If this zone does not match the first zone checked, go to 32.  
If this zone matches the first zone checked, go to 38.
- 36 If the Z component of the particle is less than or equal to the maximum Z component of the zone being checked, go to 37.  
If the Z component of the particle is greater than the Z component of the zone being checked, go to 35.
- 37 Compare the radius of the particle's position from the center line of the coil with the maximum radius of the coil.  
If the radius of the particle's position is greater, go to 33.

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- If the radius of the particle's position is less, go to 42.
- 42 Determine if the shape of the coil is conical or cylindrical.  
If the coil shape of this zone is such that its slope is negative or equal to zero, go to 46.  
If the slope of the coil in this zone is positive, go to 47.
- 46 Choose the maximum radius of the coil and go to 48.
- 47 Choose the minimum radius of the coil and go to 48.
- 48 Determine the radius of the coil at the particle Z component of position.  
If the radius of the particle's position with respect to the center line of the coil is greater than the coil radius at this Z coordinate, go to 39.  
If the radius of the particle's position is equal to or less than the radius of the coil, go to 49.
- 39 Tol is the difference between time T and the maximum significant time of flight of the particle.  
If Tol is less than or equal to the allowable tolerance, go to 33.  
If Tol is greater than the allowable tolerance, go to 139 and then to 57.
- 49 Compute some spherical radius.
- 493 ITHAT signifies the number of times this particle has been checked at this incident angle.  
If ITHAT is less than or equal to the maximum allowable number of counts, go to 507.
- 506 An angle sensing signal is set.
- 507 If JAT is less than or equal to zero, go to 510.  
If JAT is greater than zero, go to 509.
- 510 Call the subroutine TRAJ for plotting the trajectory.
- 509 Re-initiate all parameters.  
If the difference in the spherical radii of the last position and this position of the entry of the particle into the coil is equal to or greater than an allowable tolerance, go to 491.  
If it is less, go to 501.
- 501 If the number of allowable particle trajectories is less than or equal to 1, go to 491.  
If the number of allowable trajectories is greater than 1, go to 490.
- 490 Re-initiate the ITHAT count.  
Call the subroutine MLH. This is a tally of the miss and last hit.  
Give the current of the coil its initial value and go to 25.
- 491 Prepare the present coordinates for the past history tabulation and increase the value of the current for the next trajectory, then go to 24.
- 23 If JAT is less than or equal to zero, go to 52.

If it is greater than zero, go to 53.

52 Call subroutine TRAJ in preparation for tabulating trajectory information.

53 Call subroutine TIME to choose an increment of time.  
 If the time indexing subscript IT is less than or equal to the maximum indexing subscript, go to 54.  
 If it is greater, go to 55.

57 If the JAT signal is less than or equal to zero, go to 56.  
 If it is greater than zero, go to 55.

56 Call the subroutine TRAJ.

57 Call the subroutine MLH.  
 Re-initiate the current, then continue.

555 If the particle incident angle is less than  $\pi$ , go to 502.  
 If it is equal to or greater than  $\pi$ , then go to 556.

556 Choose the next particle.  
 If the subscript of the particle is less than or equal to the maximum subscript, go to 500.  
 If it is greater, then go to 30.

25 If the angle sensing signal SIS is less than or equal to zero, go to 502.  
 If it is greater than zero, go to 24.

502 If the angular increment is less than or greater than zero, go to 26.  
 If it is equal to zero, go to 27.

26 Change the angle of incidence of the particle.  
 If the new incident angle is less than or equal to zero, go to 500.  
 If it is greater, go to 27.

27 If the LAT signal is less than or equal to zero, go to 29.  
 If it is greater, go to 30.

29 Call the subroutine MLH. Choose a new particle subscript.  
 If this subscript represents a value less than or equal to the maximum allowed, go to 500.  
 If it is greater, go to 30.

30 Go to 403.

403 Call exit.

54 Determine the components of magnetic field and the cyclotron frequencies, then go to 34.

**APPENDIX II**

**DATA FROM EXAMPLE 1 PROBLEM**



**EXAMPLE I**

CHARGED PARTICLE SHIELDING

IAT=0 INDICATES A FIELD PLOT

IAT=1 INDICATES A TRAJECTORY

JAT=0 INDICATES A PLOT OF TRAJECTORY

JAT=1 INDICATES NO PLOT OF TRAJECTORY

JAT=2 INDICATES MULTIPLE CURRENT VALUES

LAT=0 INDICATES DUMP MISS AND LAST HIT

LAT=1 INDICATES NO DUMP MISS AND LAST HIT

LAT=2 MULTIPLE CURRENT FIELD PLOT

SMAX= 0 HMAX= 3 MMAX= 0 IMAX= 1 IAT= 1 JAT= 0 LAT= 0  
 AGMX=7.1999999E 01 AAAA=9.0000000E 00 BBBB=1.0000000E 03 MU=1.6724300E-27  
 DTETA0=3.0000000E 01 DTHETA=0. DR=0. RMAX=0.

ZHMAX= -5.1000000E 01 4.9999999E 01 7.1999999E 01

ZHMIN= -7.1999999E 01 -4.9999999E 01 5.1000000E 01

DZH= 1.0000000E 00 1.0000000E 00 1.0000000E 00

DA/DZ= 2.0000000E 00 0. -2.0000000E 00

AHMAX= 4.8000000E 01 4.8000000E 01 4.8000000E 01

AHMIN= 4.0000000E 00 4.8000000E 01 4.0000000E 00

EOT= 1.0000E 00

VOT= 1.4000E 07

IOT= 1.0000E 03

T=0.

XS= 0.

YS= 0.

ZS= 1.74999982E 06

T=0.01562500

SBN= 4.97416520E-16

THETA0= 0.

I= 1.00000000E 03

T=0.03125000

XS= 0.

YS=-0.

ZS= 1.53124982E 06

T=0.04687500

SBN= 5.68475968E-16

THETA0= 0.

I= 1.00000000E 03

T=0.06250000

XS=-0.

YS=-0.

ZS= 1.31249982E 06

T=0.07812500

SBN= 6.63221973E-16

THETA0= 0.

I= 1.00000000E 03

T=0.09375000

XS=-0.

YS=-0.

ZS= 1.09374982E 06

T=0.10937500

SBN= 7.95866448E-16

THETA0= 0.

I= 1.00000000E 03

T=0.12500000

XS=-0.

YS=-0.

ZS= 8.74999821E 05

T=0.14062500

SBN= 9.94833040E-16

THETA0= 0.

I= 1.00000000E 03

T=0.15625000

XS=-0.

YS=-0.

ZS= 6.56249821E 05

T=0.17187500

SBN= 1.32644424E-15

THETA0= 0.

I= 1.00000000E 03

T=0.18750000

XS=-0.

YS=-0.

ZS= 4.37499821E 05

T=0.20312500

SBN= 1.98966663E-15

THETA0= 0.

I= 1.00000000E 03

T=0.21875000

XS=-0.

YS=-0.

ZS= 2.18749827E 05

T=0.23437500

SBN= 3.97933501E-15

THETA0= 0.

I= 1.00000000E 03

T=0.25000000

XS=-0.

YS=-0.

ZS= 1.91406079E 05

T=0.26562500

SBN= 4.54781199E-15

THETA0= 0.

I= 1.00000000E 03

T=0.28125000

XS=-0.

YS=-0.

ZS= 1.64062329E 05

T=0.29687500

SBN= 5.30578136E-15

THETA0= 0.

I= 1.00000000E 03

T=0.31250000

XS=-0.

YS=-0.

ZS= 1.36718579E 05

T=0.32812500

SBN= 6.36693925E-15

THETA0= 0.

I= 1.00000000E 03

T=0.34375000

XS=-0.

YS=-0.

ZS= 1.07374829E 05

T=0.35937500

SBN= 7.95867658E-15

THETA0= 0.

I= 1.00000000E 03

T=0.37500000

XS=-0.

YS=-0.

ZS= 8.20310795E 04

T=0.39062500

SBN= 1.06115745E-14

THETA0= 0.

I= 1.00000000E 03

T=0.40625000

XS=-0.

YS=-0.

ZS= 5.46873301E 04

T=0.42187500

SBN= 1.59173799E-14

THETA0= 0.

I= 1.00000000E 03

T=0.43750000

XS=-0.

YS=-0.

ZS= 2.73435801E 04

T=0.45312500

SBN= 3.18348655E-14

THETA0= 0.

I= 1.00000000E 03

T=0.46875000

XS=-0.

YS=-0.

ZS= 2.39256114E 04

T=0.48437500

SBN= 3.63827378E-14

THETA0= 0.

I= 1.00000000E 03

T=0.50000000

XS=-0.

YS=-0.

ZS= 2.05076426E 04

T=0.51562500

SBN= 4.24465811E-14

THETA0= 0.

I= 1.00000000E 03

T=0.53125000

XS=-0.

YS=-0.

ZS= 1.70896740E 04

T=0.54687500

SBN= 5.09359896E-14

THETA0= 0.

I= 1.00000000E 03

T=0.56250000

XS=-0.

YS=-0.

ZS= 1.36717053E 04

T=0.57812500

SBN= 6.36701590E-14

THETA0= 0.

I= 1.00000000E 03

T=0.59375000

XS=-0.

YS=-0.

ZS= 1.02537365E 04

T=0.60937500

SBN= 1.48855086E-13

THETA0= 0.

I= 1.00000000E 03

T=0.62500000

XS=-0.

YS=-0.

ZS= 6.83576781E 03

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## EXAMPLE 1 (CONT'D)

T=0.12475586	SBN= 3.77665019E-13	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 3.41779912E 03
T=0.12478638	SBN= 2.78938776E-12	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 2.94055299E 03
T=0.12481689	SBN= 4.11894500E-12	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 2.56330690E 03
T=0.12484741	SBN= 6.57323349E-12	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 2.13606080E 03
T=0.12487793	SBN= 1.13058440E-11	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 1.70881473E 03
T=0.12490845	SBN= 2.20860159E-11	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 1.28156863E 03
T=0.12493896	SBN= 5.23919529E-11	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 8.54322541E 02
T=0.12496948	SBN= 1.75960638E-10	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 4.27076447E 02
T=0.12497330	SBN= 1.40506244E-09	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 3.73670688E 02
T=0.12497711	SBN= 2.09752175E-09	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 3.20264927E 02
T=0.12498093	SBN= 3.33018425E-09	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 2.66859165E 02
T=0.12498474	SBN= 5.75600576E-09	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 2.13453403E 02
T=0.12498856	SBN= 1.12454656E-08	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 1.60047641E 02
T=0.12499237	SBN= 2.66758913E-08	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 1.06641880E 02
T=0.12499619	SBN= 9.01944184E-08	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 5.32361186E 01
T=0.12499666	SBN= 7.25694305E-07	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 4.65603983E 01
T=0.12499714	SBN= 1.08512737E-06	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 3.98846781E 01
T=0.12499762	SBN= 1.72721200E-06	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 3.32089579E 01
T=0.12499809	SBN= 2.99484503E-06	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 2.65332377E 01
T=0.12499857	SBN= 5.88077688E-06	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 1.98575176E 01
T=0.12499905	SBN= 1.40738671E-05	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 1.31817974E 01
T=0.12499952	SBN= 4.85342789E-05	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 6.50607735E 00
T=0.12499958	SBN= 4.22011656E-04	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 5.67161232E 00
T=0.12499964	SBN= 6.48244804E-04	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 4.83714730E 00
T=0.12499970	SBN= 1.07267271E-03	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 4.00268227E 00
T=0.12499976	SBN= 1.97378920E-03	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 3.16821724E 00
T=0.12499982	SBN= 4.27874273E-03	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 2.33375221E 00
T=0.12499988	SBN= 1.26322816E-02	THETA0= 0.	I= 1.00000000E 03
	XS=-0.	YS=-0.	ZS= 1.49928719E 00
T=0.	SBN= 0.	THETA0= 0.	I= 1.00000000E 03
	XS= 0.	YS= 0.	ZS= 1.74999982E 06
T=0.01562500	SBN= 4.97416443E-15	THETA0= 0.	I= 1.00000000E 04
	XS= 0.	YS=-0.	ZS= 1.53124982E 06
T=0.03125000	SBN= 5.68476003E-15	THETA0= 0.	I= 1.00000000E 04
	XS=-0.	YS=-0.	ZS= 1.31249982E 06

## EXAMPLE 1 (Cont'd)

T=0.04687500	SBN= 6.63222045E-15 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.09374982E 06
T=0.06250000	SBN= 7.95866418E-15 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 8.74999821E 05
T=0.07812500	SBN= 9.94833148E-15 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 6.56249821E 05
T=0.09375000	SBN= 1.32644427E-14 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 4.37499821E 05
T=0.10937500	SBN= 1.98966663E-14 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 2.18749827E 05
T=0.11132813	SBN= 3.97933495E-14 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.91406079E 05
T=0.11328125	SBN= 4.54781199E-14 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.64062329E 05
T=0.11523438	SBN= 5.30578160E-14 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.36718579E 05
T=0.11718750	SBN= 6.36693931E-14 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.09374829E 05
T=0.11914063	SBN= 7.95867658E-14 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 8.20310795E 04
T=0.12109375	SBN= 1.06115751E-13 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 5.46873301E 04
T=0.12304688	SBN= 1.59173797E-13 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 2.73435801E 04
T=0.12329102	SBN= 3.18348652E-13 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 2.39256114E 04
T=0.12353516	SBN= 3.63827384E-13 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 2.05076426E 04
T=0.12377930	SBN= 4.24465823E-13 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.70896740E 04
T=0.12402344	SBN= 5.09359890E-13 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.36717053E 04
T=0.12426758	SBN= 6.36701548E-13 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.02537365E 04
T=0.12451172	SBN= 1.48855092E-12 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 6.83576781E 03
T=0.12475586	SBN= 3.77665004E-12 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 3.41779912E 03
T=0.12478638	SBN= 2.78938791E-11 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 2.99055299E 03
T=0.12481689	SBN= 4.11894494E-11 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 2.56330690E 03
T=0.12484741	SBN= 6.57323307E-11 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 2.13606080E 03
T=0.12487793	SBN= 1.13058445E-10 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.70881473E 03
T=0.12490845	SBN= 2.20860165E-10 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.28156863E 03
T=0.12493896	SBN= 5.23919517E-10 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 8.54322541E 02
T=0.12496948	SBN= 1.75960639E-09 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 4.27076447E 02
T=0.12497330	SBN= 1.40506251E-08 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 3.73670688E 02
T=0.12497711	SBN= 2.09752175E-08 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 3.20264927E 02
T=0.12498093	SBN= 3.33018428E-08 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 2.66859165E 02
T=0.12498474	SBN= 5.75600582E-08 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 2.13453403E 02
T=0.12498856	SBN= 1.12454663E-07 XS=-0.	THETA0= 0. YS=-0.	I= 1.00000000E 04 ZS= 1.60047641E 02

## EXAMPLE 1 (Cont'd)

```

I=0.12499237      SBN= 2.66758895E-07      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 1.06641880E 02
SBN= 9.01944208E-07      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 5.32361186E 01
SBN= 7.25694317E-06      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 4.65603983E 01
SBN= 1.08512741E-05      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 3.98846781E 01
SBN= 1.72721192E-05      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 3.32089579E 01
SBN= 2.99484518E-05      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 2.65332377E 01
SBN= 5.8807770CE-05      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 1.98575176E 01
SBN= 1.40738663E-04      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 1.31817974E 01
SBN= 4.85342807E-04      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 6.50607735E 00
SBN= 4.22011644E-03      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 5.67161232E 00
SBN= 6.48244828E-03      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 4.83714730E 00
SBN= 1.07267272E-02      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 4.00268227E 00
SBN= 1.97378924E-02      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 3.16821724E 00
SBN= 4.27874255E-02      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 2.33375221E 00
SBN= 1.26322816E-01      THETA= 0.      I= 1.00000000E 04
XS=-0.            XS=-0.            YS=-0.      ZS= 1.49928719E 00
SBN= 0.            XS=-0.            THETA= 0.      I= 1.00000000E 04
MISS              XS=-0.            YS=-0.      ZS= 1.49928719E 00 I= 1.00000000E 04
THETA= 0.          EOT= 1.00000000E 00      VOT= 1.39999999E 07      IOT= 0.      SP1= 0
LAST HIT          XS=-0.            YS=-0.      ZS= 1.49928719E 00 I= 1.00000000E 04
THETA= 0.          EOT= 1.00000000E 00      VOT= 1.39999999E 07      IOT= 0.      SP1= 0

```

## EXAMPLE 1 (Cont'd)

T=0.	XS= 8.74999881E 05	YS= 0.	ZS= 1.51554431E 06
	SBN= 5.99625260E-16	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.01562500	XS= 7.65624887E 05	YS= 1.95860074E-04	ZS= 1.32610126E 06
	SBN= 3.52458900E-16	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.03125000	XS= 6.56249887E 05	YS= 3.77730146E-04	ZS= 1.13665819E 06
	SBN= 2.27130863E-16	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.04687500	XS= 5.46874887E 05	YS= 6.33789676E-04	ZS= 9.47215128E 05
	SBN= 3.81702700E-16	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.06250000	XS= 4.37499893E 05	YS= 9.77541125E-04	ZS= 7.57772076E 05
	SBN= 6.88944006E-16	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.07812500	XS= 3.28124896E 05	YS= 1.45705922E-03	ZS= 5.68329012E 05
	SBN= 1.32113637E-15	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.09375000	XS= 2.18749902E 05	YS= 1.86387175E-03	ZS= 3.78885955E 05
	SBN= 2.15319857E-15	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.10937500	XS= 1.09374905E 05	YS= 2.97399968E-03	ZS= 1.89442900E 05
	SBN= 1.36278419E-15	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.11132813	XS= 9.57030308E 04	YS= 3.11972088E-03	ZS= 1.65762517E 05
	SBN= 4.76621687E-15	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.11328125	XS= 8.20311558E 04	YS= 3.28428090E-03	ZS= 1.42082134E 05
	SBN= 8.72181523E-16	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.11523438	XS= 6.83592808E 04	YS= 3.45180848E-03	ZS= 1.18401751E 05
	SBN= 8.85262752E-15	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.11718750	XS= 5.46874064E 04	YS= 3.66229165E-03	ZS= 9.47213686E 04
	SBN= 1.01353662E-14	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.11914063	XS= 4.10155320E 04	YS= 3.91770560E-03	ZS= 7.10409862E 04
	SBN= 1.00300527E-14	THETA0= 5.23598766E-01	I= 1.00000000E 03
T=0.12109375	XS= 2.73436576E 04	YS= 4.22134250E-03	ZS= 4.73606038E 04

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## EXAMPLE 1 (Cont'd)

T=0.12304688	SBN= 2.73648283E-14	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.36717832E 04	YS= 4.65365076E-03	ZS= 2.36802217E 04
T=0.12329102	SBN= 5.75632292E-14	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.19627988E 04	YS= 4.71224493E-03	ZS= 2.07201740E 04
T=0.12353516	SBN= 6.87767619E-14	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.02538145E 04	YS= 4.77632374E-03	ZS= 1.77601261E 04
T=0.12377930	SBN= 1.10183725E-13	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 8.54483032E 03	YS= 4.84918916E-03	ZS= 1.48000783E 04
T=0.12402344	SBN= 9.07442772E-14	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 6.83584607E 03	YS= 4.92870367E-03	ZS= 1.18400304E 04
T=0.12426758	SBN= 9.31348213E-14	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 5.12686181E 03	YS= 5.01385182E-03	ZS= 8.87998259E 03
T=0.12451172	SBN= 1.51193041E-13	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 3.41787758E 03	YS= 5.10754305E-03	ZS= 5.91993487E 03
T=0.12475586	SBN= 3.52879831E-13	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.70889340E 03	YS= 5.20850229E-03	ZS= 2.95988712E 03
T=0.12478638	SBN= 2.47041413E-12	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.49527037E 03	YS= 5.22060496E-03	ZS= 2.58988112E 03
T=0.12481689	SBN= 3.67390141E-12	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.28164734E 03	YS= 5.23191911E-03	ZS= 2.21987516E 03
T=0.12484741	SBN= 5.84804684E-12	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.06802431E 03	YS= 5.24174023E-03	ZS= 1.84986918E 03
T=0.12487793	SBN= 9.97370625E-12	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 8.54401278E 02	YS= 5.24878860E-03	ZS= 1.47986318E 03
T=0.12490845	SBN= 1.97737338E-11	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 6.40778255E 02	YS= 5.24981248E-03	ZS= 1.10985720E 03
T=0.12493896	SBN= 4.65588874E-11	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 4.27155232E 02	YS= 5.23571098E-03	ZS= 7.39851230E 02
T=0.12496948	SBN= 1.57646234E-10	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 2.13532212E 02	YS= 5.16959369E-03	ZS= 3.69845262E 02
T=0.12497330	SBN= 1.26541419E-09	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.86829333E 02	YS= 5.15451992E-03	ZS= 3.23594517E 02
T=0.12497711	SBN= 1.88904755E-09	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.60126455E 02	YS= 5.12927151E-03	ZS= 2.77343768E 02
T=0.12498093	SBN= 2.99954161E-09	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.33423577E 02	YS= 5.08786434E-03	ZS= 2.31093019E 02
T=0.12498474	SBN= 5.18538064E-09	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.06720701E 02	YS= 5.01853877E-03	ZS= 1.84842274E 02
T=0.12498856	SBN= 1.01343016E-08	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 8.00178230E 01	YS= 4.89460450E-03	ZS= 1.38591525E 02
T=0.12499237	SBN= 2.40469122E-08	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 5.33149469E 01	YS= 4.64091760E-03	ZS= 9.23407781E 01
T=0.12499619	SBN= 8.13111842E-08	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 2.66120714E 01	YS= 3.94807062E-03	ZS= 4.60900325E 01
T=0.12499666	SBN= 6.54346675E-07	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 2.32742116E 01	YS= 3.80614763E-03	ZS= 4.03086889E 01
T=0.12499714	SBN= 9.78431046E-07	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.99363521E 01	YS= 3.58147004E-03	ZS= 3.45273459E 01
T=0.12499762	SBN= 1.55735581E-06	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.65984924E 01	YS= 3.22496685E-03	ZS= 2.87460023E 01
T=0.12499809	SBN= 2.70011890E-06	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 1.32606331E 01	YS= 2.63962209E-03	ZS= 2.29646593E 01
T=0.12499857	SBN= 5.30094850E-06	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 9.92277384E 00	YS= 1.60403715E-03	ZS= 1.71833161E 01
T=0.12499905	SBN= 1.26787700E-05	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 6.58491486E 00	YS= -5.13255537E-04	ZS= 1.14019729E 01
T=0.12499952	SBN= 4.36341560E-05	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 3.24705833E 00	YS= -6.39902085E-03	ZS= 5.62062985E 00
T=0.12499958	SBN= 3.74858990E-04	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 2.82982719E 00	YS= -7.67184287E-03	ZS= 4.89796191E 00
T=0.12499964	SBN= 5.73186457E-04	THETA0= 5.23598766E-01	I= 1.00000000E 03
	XS= 2.41259861E 00	YS= -9.78445196E-03	ZS= 4.17529398E 00

## EXAMPLE 1 (Cont'd)

T=0.12499970	SBN= 9.42461991E-04 XS= 1.99537727E 00	THETA0= 5.23598766E-01 YS=-1.33229573E-02	I= 1.00000000E 03 ZS= 3.45262608E 00
T=0.12499976	SBN= 1.71960224E-03 XS= 1.57817908E 00	THETA0= 5.23598766E-01 YS=-1.95896231E-02	I= 1.00000000E 03 ZS= 2.72995818E 00
T=0.12499982	SBN= 3.69510159E-03 XS= 1.16107517E 00	THETA0= 5.23598766E-01 YS=-3.21333748E-02	I= 1.00000000E 03 ZS= 2.00729030E 00
T=0.12499988	SBN= 1.07898226E-02 XS= 7.44546920E-01	THETA0= 5.23598766E-01 YS=-6.38184482E-02	I= 1.00000000E 03 ZS= 1.28462243E 00
T=0.12499994	SBN= 3.68290862E-02 XS= 3.23012000E-01	THETA0= 5.23598766E-01 YS=-2.96864688E-02	I= 1.00000000E 03 ZS= 5.61954570E-01
T=0.	SBN= 0. XS= 8.74999881E 05	THETA0= 5.23598766E-01 YS= 0.	I= 1.00000000E 03 ZS= 1.51554431E 06
T=0.01562500	SBN= 5.99625403E-15 XS= 7.65624887E 05	THETA0= 5.23598766E-01 YS= 1.95860094E-03	I= 1.00000000E 04 ZS= 1.32610126E 06
T=0.03125000	SBN= 3.52458903E-15 XS= 6.56249887E 05	THETA0= 5.23598766E-01 YS= 3.77730185E-03	I= 1.00000000E 04 ZS= 1.13665819E 06
T=0.04687500	SBN= 2.27130869E-15 XS= 5.46874887E 05	THETA0= 5.23598766E-01 YS= 6.33789736E-03	I= 1.00000000E 04 ZS= 9.47215128E 05
T=0.06250000	SBN= 3.81702703E-15 XS= 4.37499893E 05	THETA0= 5.23598766E-01 YS= 9.77541208E-03	I= 1.00000000E 04 ZS= 7.57172076E 05
T=0.07812500	SBN= 6.88944012E-15 XS= 3.28124896E 05	THETA0= 5.23598766E-01 YS= 1.45705932E-02	I= 1.00000000E 04 ZS= 5.68329012E 05
T=0.09375000	SBN= 1.32113615E-14 XS= 2.18749902E 05	THETA0= 5.23598766E-01 YS= 1.86387186E-02	I= 1.00000000E 04 ZS= 3.78885955E 05
T=0.10937500	SBN= 4.63346863E-15 XS= 1.09374911E 05	THETA0= 5.23598766E-01 YS= 2.40422538E-02	I= 1.00000000E 04 ZS= 1.89442900E 05
T=0.11132813	SBN= 1.47180682E-14 XS= 9.57030380E 04	THETA0= 5.23598766E-01 YS= 2.47928125E-02	I= 1.00000000E 04 ZS= 1.65762517E 05
T=0.11328125	SBN= 4.76055920E-14 XS= 8.20311642E 04	THETA0= 5.23598766E-01 YS= 2.57190406E-02	I= 1.00000000E 04 ZS= 1.42082134E 05
T=0.11523438	SBN= 8.72181463E-15 XS= 6.83592898E 04	THETA0= 5.23598766E-01 YS= 2.66749445E-02	I= 1.00000000E 04 ZS= 1.18401751E 05
T=0.11718750	SBN= 9.38559234E-14 XS= 5.46874166E 04	THETA0= 5.23598766E-01 YS= 2.80654120E-02	I= 1.00000000E 04 ZS= 9.47213686E 04
T=0.11914063	SBN= 8.06765985E-14 XS= 4.10155427E 04	THETA0= 5.23598766E-01 YS= 2.98676291E-02	I= 1.00000000E 04 ZS= 7.10409862E 04
T=0.12109375	SBN= 1.46289188E-13 XS= 2.73436695E 04	THETA0= 5.23598766E-01 YS= 3.23078719E-02	I= 1.00000000E 04 ZS= 4.73606038E 04
T=0.12304688	SBN= 2.77236626E-13 XS= 1.36717965E 04	THETA0= 5.23598766E-01 YS= 3.60570851E-02	I= 1.00000000E 04 ZS= 2.36802217E 04
T=0.12329102	SBN= 4.58600926E-13 XS= 1.19628124E 04	THETA0= 5.23598766E-01 YS= 3.65585563E-02	I= 1.00000000E 04 ZS= 2.07201740E 04
T=0.12353516	SBN= 5.90718216E-13 XS= 1.02538282E 04	THETA0= 5.23598766E-01 YS= 3.71050373E-02	I= 1.00000000E 04 ZS= 1.77601261E 04
T=0.12377930	SBN= 8.58564579E-13 XS= 8.54484403E 03	THETA0= 5.23598766E-01 YS= 3.77164328E-02	I= 1.00000000E 04 ZS= 1.48000783E 04
T=0.12402344	SBN= 8.50801504E-13 XS= 6.83585995E 03	THETA0= 5.23598766E-01 YS= 3.83913982E-02	I= 1.00000000E 04 ZS= 1.18400304E 04
T=0.12426758	SBN= 1.11073051E-12 XS= 5.12687588E 03	THETA0= 5.23598766E-01 YS= 3.91497374E-02	I= 1.00000000E 04 ZS= 8.87498259E 03
T=0.12451172	SBN= 1.28007951E-12 XS= 3.41789183E 03	THETA0= 5.23598766E-01 YS= 3.99445909E-02	I= 1.00000000E 04 ZS= 5.91993487E 03
T=0.12475586	SBN= 3.49767178E-12 XS= 1.70890778E 03	THETA0= 5.23598766E-01 YS= 4.07311010E-02	I= 1.00000000E 04 ZS= 2.95988712E 03
T=0.12478638	SBN= 2.45631826E-11 XS= 1.49528477E 03	THETA0= 5.23598766E-01 YS= 4.08251172E-02	I= 1.00000000E 04 ZS= 2.58988112E 03
T=0.12481689	SBN= 3.62541381E-11 XS= 1.28166175E 03	THETA0= 5.23598766E-01 YS= 4.09100187E-02	I= 1.00000000E 04 ZS= 2.21987516E 03
T=0.12484741	SBN= 5.81761956E-11 XS= 1.06803873E 03	THETA0= 5.23598766E-01 YS= 4.09816211E-02	I= 1.00000000E 04 ZS= 1.84986918E 03
T=0.12487793	SBN= 9.99621522E-11 XS= 8.54415727E 02	THETA0= 5.23598766E-01 YS= 4.10248017E-02	I= 1.00000000E 04 ZS= 1.47986318E 03

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## EXAMPLE 1 (Cont'd)

T=0.12490845	SBN= 1.96053205E-10	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 6.40792722E 02	YS= 4.10064465E-C2	ZS= 1.10985720E 03
T=0.12493896	SBN= 4.65425569E-10	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 4.27169716E 02	YS= 4.08374840E-02	ZS= 7.39851230E 02
T=0.12496948	SBN= 1.57798176E-09	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 2.13546714E 02	YS= 4.01423694E-C2	ZS= 3.69845262E 02
T=0.12497330	SBN= 1.26479228E-08	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 1.86843841E 02	YS= 3.99873549E-02	ZS= 3.23594517E 02
T=0.12497711	SBN= 1.88851875E-08	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 1.60140966E 02	YS= 3.97307834E-02	ZS= 2.77343768E 02
T=0.12498093	SBN= 2.99960500E-08	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 1.33438091E 02	YS= 3.93123487E-02	ZS= 2.31093019E 02
T=0.12498474	SBN= 5.18553823E-08	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 1.06735216E 02	YS= 3.86145145E-02	ZS= 1.84842274E 02
T=0.12498856	SBN= 1.01315154E-07	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 8.00323415E 01	YS= 3.73706412E-02	ZS= 1.38591525E 02
T=0.12499237	SBN= 2.40415302E-07	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 5.33294672E 01	YS= 3.48289058E-02	ZS= 9.23407781E 01
T=0.12499619	SBN= 8.12896132E-07	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 2.66265941E 01	YS= 2.78942740E-02	ZS= 4.60900325E 01
T=0.12499666	SBN= 6.54007715E-06	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 2.32887349E 01	YS= 2.64738414E-02	ZS= 4.03086889E 01
T=0.12499714	SBN= 9.77862215E-06	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 1.99508764E 01	YS= 2.42250890E-02	ZS= 3.45273459E 01
T=0.12499762	SBN= 1.55630989E-05	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 1.66130184E 01	YS= 2.06566024E-02	ZS= 2.87460023E 01
T=0.12499809	SBN= 2.69792882E-05	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 1.32751630E 01	YS= 1.47967708E-02	ZS= 2.29646390E 01
T=0.12499857	SBN= 5.29556543E-05	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 9.93731570E 00	YS= 4.42728388E-03	ZS= 1.71833156E 01
T=0.12499905	SBN= 1.26615058E-04	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 6.59950203E 00	YS= -1.67823896E-02	ZS= 1.14019723E 01
T=0.12499952	SBN= 4.35435170E-04	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 3.26192859E 00	YS= -7.57943451E-02	ZS= 5.62062919E 00
T=0.12499958	SBN= 3.73090750E-03	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 2.84482741E 00	YS= -8.85723615E-02	ZS= 4.89796126E 00
T=0.12499964	SBN= 5.69914120E-03	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 2.42798504E 00	YS= -1.09798740E-01	ZS= 4.17529333E 00
T=0.12499970	SBN= 9.35434604E-03	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 2.01187322E 00	YS= -1.45371147E-01	ZS= 3.45262542E 00
T=0.12499976	SBN= 1.70015918E-02	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 1.59810607E 00	YS= -2.08370700E-01	ZS= 2.72995752E 00
T=0.12499982	SBN= 3.61025286E-02	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 1.19390613E 00	YS= -3.34205571E-01	ZS= 2.00728965E 00
T=0.12499988	SBN= 9.97852528E-02	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 8.48434436E-01	YS= -6.48684144E-01	ZS= 1.28462178E 00
T=0.12499994	SBN= 4.34162247E-01	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 2.32929036E-01	YS= -6.66516113E-01	ZS= 5.61953914E-01
T=0.	SBN= 0.	THETA0= 5.23598766E-01	I= 1.00000000E 04
	XS= 8.74999881E 05	YS= 0.	ZS= 1.51554431E 06
T=0.01562500	SBN= 5.45659071E-14	THETA0= 5.23598766E-01	I= 9.09999990E 04
	XS= 7.65624887E 05	YS= 1.78232698E-02	ZS= 1.32610126E 06
T=0.03125000	SBN= 3.20737600E-14	THETA0= 5.23598766E-01	I= 9.09999990E 04
	XS= 6.56249887E 05	YS= 3.43734491E-02	ZS= 1.13665819E 06
T=0.04687500	SBN= 2.0668909CE-14	THETA0= 5.23598766E-01	I= 9.09999990E 04
	XS= 5.46874887E 05	YS= 5.76748693E-02	ZS= 9.47215128E 05
T=0.06250000	SBN= 3.47349450E-14	THETA0= 5.23598766E-01	I= 9.09999990E 04
	XS= 4.37499893E 05	YS= 8.89562535E-02	ZS= 7.57772076E 05
T=0.07812500	SBN= 6.26939023E-14	THETA0= 5.23598766E-01	I= 9.09999990E 04
	XS= 3.28124896E 05	YS= 1.32592404E-01	ZS= 5.68329012E 05
T=0.09375000	SBN= 1.20223415E-13	THETA0= 5.23598766E-01	I= 9.09999990E 04
	XS= 2.18749902E 05	YS= 1.69612345E-01	ZS= 3.78885955E 05



## EXAMPLE 1 (Cont'd)

T=0.10937500	SBN= 4.21645635E-14	THETAO= 5.23598766E-01	I= 9.09999990E 04
	XS= 1.09374911E 05	YS= 2.18784517E-01	ZS= 1.89442900E 05
	SBN= 1.33934419E-13	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.11132813	XS= 9.57030380E 04	YS= 2.25614601E-01	ZS= 1.65762517E 05
	SBN= 4.33210856E-13	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.11328125	XS= 8.20311642E 04	YS= 2.34043276E-01	ZS= 1.42082134E 05
	SBN= 7.93685126E-14	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.11523438	XS= 6.83592898E 04	YS= 2.42742002E-01	ZS= 1.18401751E 05
	SBN= 8.54088902E-13	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.11718750	XS= 5.46874166E 04	YS= 2.55395254E-01	ZS= 9.47213686E 04
	SBN= 7.34156996E-13	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.11914063	XS= 4.10155427E 04	YS= 2.71795431E-01	ZS= 7.10409862E 04
	SBN= 1.33123183E-12	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12109375	XS= 2.73436695E 04	YS= 2.94001642E-01	ZS= 4.73606038E 04
	SBN= 2.52285346E-12	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12304688	XS= 1.36717965E 04	YS= 3.28119481E-01	ZS= 2.36802217E 04
	SBN= 4.17326820E-12	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12329102	XS= 1.19628124E 04	YS= 3.32682869E-01	ZS= 2.07201740E 04
	SBN= 5.37553537E-12	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12353516	XS= 1.02538282E 04	YS= 3.37655845E-01	ZS= 1.77601261E 04
	SBN= 7.81293780E-12	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12377930	XS= 8.54484403E 03	YS= 3.43219548E-01	ZS= 1.48000783E 04
	SBN= 7.74229228E-12	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12402344	XS= 6.83585995E 03	YS= 3.49361733E-01	ZS= 1.18400304E 04
	SBN= 1.01076473E-11	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12426758	XS= 5.12687588E 03	YS= 3.56262615E-01	ZS= 8.87998259E 03
	SBN= 1.16487241E-11	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12451172	XS= 3.41789183E 03	YS= 3.63495785E-01	ZS= 5.91993487E 03
	SBN= 3.13464960E-11	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12475586	XS= 1.70890781E 03	YS= 3.71295410E-01	ZS= 2.95988712E 03
	SBN= 2.24275646E-10	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12478638	XS= 1.49528480E 03	YS= 3.72229624E-01	ZS= 2.58988112E 03
	SBN= 3.29098102E-10	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12481689	XS= 1.28166176E 03	YS= 3.73080048E-01	ZS= 2.21987516E 03
	SBN= 5.33841622E-10	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12484741	XS= 1.06803875E 03	YS= 3.73782223E-01	ZS= 1.84986918E 03
	SBN= 9.09414876E-10	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12487793	XS= 8.54415739E 02	YS= 3.74229002E-01	ZS= 1.47986318E 03
	SBN= 1.78430790E-09	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12490845	XS= 6.40792739E 02	YS= 3.74116006E-01	ZS= 1.10985720E 03
	SBN= 4.23544306E-09	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12493896	XS= 4.27169734E 02	YS= 3.72633803E-01	ZS= 7.39851230E 02
	SBN= 1.43085200E-08	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12496948	XS= 2.13546732E 02	YS= 3.66441509E-01	ZS= 3.69845262E 02
	SBN= 1.15127730E-07	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12497330	XS= 1.86843859E 02	YS= 3.65049127E-01	ZS= 3.23594517E 02
	SBN= 1.71858864E-07	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12497711	XS= 1.60140982E 02	YS= 3.62731770E-01	ZS= 2.77343768E 02
	SBN= 2.72918949E-07	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12498093	XS= 1.33438107E 02	YS= 3.58945140E-01	ZS= 2.31093019E 02
	SBN= 4.71843117E-07	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12498474	XS= 1.06735234E 02	YS= 3.52617535E-01	ZS= 1.84842274E 02
	SBN= 9.22188616E-07	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12498856	XS= 8.00323606E 01	YS= 3.41315258E-01	ZS= 1.38591525E 02
	SBN= 2.18771857E-06	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12499237	XS= 5.33294928E 01	YS= 3.18204600E-01	ZS= 9.23407781E 01
	SBN= 7.39739656E-06	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12499619	XS= 2.66266599E 01	YS= 2.55109090E-01	ZS= 4.60900325E 01
	SBN= 5.95122355E-05	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12499666	XS= 2.32888177E 01	YS= 2.42183891E-01	ZS= 4.03086889E 01
	SBN= 8.89815080E-05	THETAO= 5.23598766E-01	I= 9.09999990E 04
T=0.12499714	XS= 1.99510045E 01	YS= 2.21720162E-01	ZS= 3.45273459E 01

## EXAMPLE 1 (Cont'd)

	SBN= 1.41615552E-04	THETA0= 5.23598766E-01	I= 9.01999990E 04
T=0.12499762	XS= 1.66132651E 01	YS= 1.89245924E-01	ZS= 2.87460023E 01
	SBN= 2.45494032E-04	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499809	XS= 1.32757287E 01	YS= 1.35918935E-01	ZS= 2.29646590E 01
	SBN= 4.81853497E-04	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499857	XS= 9.93884802E 00	YS= 4.15555513E-02	ZS= 1.71833159E 01
	SBN= 1.15202455E-03	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499905	XS= 6.60475606E 00	YS=-1.51426376E-01	ZS= 1.14019726E 01
	SBN= 3.95852804E-03	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499952	XS= 3.29055926E 00	YS=-6.88130218E-01	ZS= 5.62062967E 00
	SBN= 3.29504389E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499958	XS= 2.88436535E 00	YS=-8.05117249E-01	ZS= 4.89746174E 00
	SBN= 4.92103440E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499964	XS= 2.50030756E 00	YS=-9.98963726E-01	ZS= 4.17529386E 00
	SBN= 7.61023402E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499970	XS= 2.17861009E 00	YS=-1.31636144E 00	ZS= 3.45262599E 00
	SBN= 1.16113782E-01	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499976	XS= 2.04136419E 00	YS=-1.82070948E 00	ZS= 2.72995815E 00
	SBN= 1.44860710E-01	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499982	XS= 2.35086638E 00	YS=-2.44662902E 00	ZS= 2.00729030E 00
	SBN= 1.11957596E-01	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499988	XS= 2.39211169E 00	YS=-3.20519513E 00	ZS= 1.26462248E 00
	SBN= 7.93218619E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499994	XS= 2.43209299E 00	YS=-3.96382996E 00	ZS= 5.61954659E-01
	SBN= 5.23858684E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499995	XS= 2.43904898E 00	YS=-4.05855608E 00	ZS= 4.71621186E-01
	SBN= 4.96550816E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499996	XS= 2.44806322E 00	YS=-4.15313107E 00	ZS= 3.81287709E-01
	SBN= 4.70463049E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499996	XS= 2.45920953E 00	YS=-4.24750280E 00	ZS= 2.90954232E-01
	SBN= 4.45616293E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499997	XS= 2.47253788E 00	YS=-4.34161687E 00	ZS= 2.00620756E-01
	SBN= 4.2201606CE-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499998	XS= 2.48807681E 00	YS=-4.43541783E 00	ZS= 1.10287280E-01
	SBN= 3.99654624E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499999	XS= 2.50583595E 00	YS=-4.52885103E 00	ZS= 1.99538060E-02
	SBN= 3.78512147E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12499999	XS= 2.52580839E 00	YS=-4.62186354E 00	ZS=-7.03796685E-02
	SBN= 3.58558762E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12500000	XS= 2.54797307E 00	YS=-4.71440530E 00	ZS=-1.60713141E-01
	SBN= 3.39756146E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12500001	XS= 2.57229695E 00	YS=-4.80642992E 00	ZS=-2.51046613E-01
	SBN= 3.22059727E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12500001	XS= 2.59873712E 00	YS=-4.89789516E 00	ZS=-3.41380084E-01
	SBN= 3.05420542E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12500002	XS= 2.62724274E 00	YS=-4.98876333E 00	ZS=-4.31713551E-01
	SBN= 2.89786437E-02	THETA0= 5.23598766E-01	I= 9.09999990E 04
T=0.12500003	XS= 2.65775678E 00	YS=-5.07900143E 00	ZS=-5.22047019E-01

## EXAMPLE 1 (Cont'd)

T=0.12500004 SBN= 2.75103682E-02 THETA= 5.23598766E-01 I= 9.09999990E 04  
 XS= 2.69021738E 00 YS= 5.16858131E C0 ZS= -6.12380487E-01  
 SBN= 2.61318126E-02 THETA= 5.23598766E-01 I= 9.09999990E 04  
 XS= 2.69021738E 00 YS= 5.16858131E 00 ZS= -6.12380487E-01 I= 9.09999990E 04  
 MISS THETA= 5.23598766E-01 EOT= 1.00000000E 00 VOT= 1.39999999E 07 IOT= 0. SBN= 2.  
 LAST HIT XS= 2.32929036E-01 YS= -6.66516113E-01 ZS= 5.61953914E-01 I= 1.00000000E C4  
 THETA= 5.23598766E-01 EOT= 1.00000000E 00 VOT= 1.39999999E 07 IOT= 0. SBN= 0.  
 I=0. XS= 1.51554427E 06 YS= 0. ZS= 8.74999917E 05  
 SBN= 1.87203191E-16 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 1.32610121E 06 YS= 4.49750334E-C6 ZS= 7.65624917E 05  
 SBN= 3.74010596E-16 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 1.13665815E 06 YS= 3.13907006E-05 ZS= 6.56249911E 05  
 SBN= 6.52400488E-16 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 9.47215092E 05 YS= -9.20608616E-05 ZS= 5.46874905E 05  
 SBN= 5.03115183E-16 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 7.57772040E 05 YS= -2.07545429E-04 ZS= 4.37499899E 05  
 SBN= 5.79928273E-16 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 5.68328989E 05 YS= -1.46985295E-04 ZS= 3.28124896E 05  
 SBN= 7.59159696E-16 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 3.78885940E 05 YS= -2.29488161E-04 ZS= 2.18749896E 05  
 SBN= 1.90645631E-15 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 1.89442889E 05 YS= 2.84247398E-04 ZS= 1.09374894E 05  
 SBN= 2.17924583E-15 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 1.65762506E 05 YS= 3.45693576E-04 ZS= 9.57030189E 04  
 SBN= 2.31456327E-15 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 1.42082123E 05 YS= 4.16341221E-04 ZS= 8.20311427E 04  
 SBN= 8.36746764E-16 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 1.18401742E 05 YS= 4.88595116E-04 ZS= 6.83592677E 04  
 SBN= 5.96181363E-15 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 9.47213614E 04 YS= 5.88926071E-04 ZS= 5.46873921E 04  
 SBN= 4.49804932E-15 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 7.10409796E 04 YS= 7.08371252E-04 ZS= 4.10155165E 04  
 SBN= 5.97674662E-15 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 4.73605978E 04 YS= 8.42647326E-04 ZS= 2.73436412E 04  
 SBN= 2.77182099E-14 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 2.36802167E 04 YS= 1.11337218E-03 ZS= 1.36717662E 04  
 SBN= 6.47833133E-14 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 2.07201689E 04 YS= 1.15228736E-03 ZS= 1.19627817E 04  
 SBN= 2.60383400E-14 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 1.77601211E 04 YS= 1.19313858E-03 ZS= 1.02537972E 04  
 SBN= 2.88745967E-14 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 1.48000734E 04 YS= 1.23570979E-03 ZS= 8.54481268E 03  
 SBN= 3.71648958E-14 THETA= 1.04719754E 00 I= 1.00000000E 03  
 XS= 1.18400256E 04 YS= 1.28067419E-03 ZS= 6.83582830E 03

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## EXAMPLE 1 (Cont'd)

T=0.12426758	SBN= 3.83258954E-14	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 8.87997782E 03	YS= 1.32788225E-03	ZS= 5.12684387E 03
T=0.12451172	SBN= 7.03748041E-14	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 5.91993022E 03	YS= 1.37494315E-03	ZS= 3.41785946E 03
T=0.12475586	SBN= 2.52708134E-13	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 2.95988256E 03	YS= 1.40794121E-03	ZS= 1.70887507E 03
T=0.12478638	SBN= 1.75028838E-12	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 2.58987659E 03	YS= 1.41069536E-03	ZS= 1.49525201E 03
T=0.12481689	SBN= 2.67065880E-12	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 2.21987060E 03	YS= 1.41132577E-03	ZS= 1.28162895E 03
T=0.12484741	SBN= 4.15660727E-12	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 1.84986463E 03	YS= 1.40870796E-03	ZS= 1.06800589E 03
T=0.12487793	SBN= 7.18311238E-12	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 1.47985867E 03	YS= 1.40052226E-03	ZS= 8.54382825E 02
T=0.12490845	SBN= 1.41425711E-11	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 1.10985272E 03	YS= 1.38121949E-03	ZS= 6.40759778E 02
T=0.12493896	SBN= 3.40721655E-11	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 7.39846766E 02	YS= 1.33456188E-03	ZS= 4.27136725E 02
T=0.12496948	SBN= 1.15255839E-10	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 3.69840828E 02	YS= 1.19480796E-03	ZS= 2.13513681E 02
T=0.12497330	SBN= 9.27430010E-10	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 3.23590082E 02	YS= 1.16554150E-03	ZS= 1.86810797E 02
T=0.12497711	SBN= 1.38549213E-09	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 2.77339339E 02	YS= 1.11862916E-03	ZS= 1.60107915E 02
T=0.12498093	SBN= 2.20060202E-09	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 2.31088597E 02	YS= 1.04369006E-03	ZS= 1.33405033E 02
T=0.12498474	SBN= 3.80484438E-09	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 1.84837855E 02	YS= 9.20271254E-04	ZS= 1.06702150E 02
T=0.12498856	SBN= 7.43600786E-09	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 1.38587114E 02	YS= 7.02090210E-04	ZS= 7.99992687E 01
T=0.12499237	SBN= 1.76456159E-08	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 9.23363733E 01	YS= 2.58938473E-04	ZS= 5.32963878E 01
T=0.12499619	SBN= 5.96659827E-08	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 4.60856342E 01	YS= -9.45023370E-04	ZS= 2.65935069E 01
T=0.12499666	SBN= 4.80047250E-07	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 4.03042918E 01	YS= -1.19122364E-03	ZS= 2.32556465E 01
T=0.12499714	SBN= 7.17745411E-07	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 3.45229495E 01	YS= -1.58054501E-03	ZS= 1.99177864E 01
T=0.12499762	SBN= 1.14224601E-06	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 2.87416071E 01	YS= -2.19768935E-03	ZS= 1.65799263E 01
T=0.12499809	SBN= 1.97987023E-06	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 2.29602650E 01	YS= -3.20985746E-03	ZS= 1.32420662E 01
T=0.12499857	SBN= 3.88490909E-06	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 1.71789230E 01	YS= -4.99754572E-03	ZS= 9.90420628E 00
T=0.12499905	SBN= 9.28096282E-06	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 1.13975815E 01	YS= -8.63958859E-03	ZS= 6.56634623E 00
T=0.12499952	SBN= 3.18293935E-05	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 5.61624432E 00	YS= -1.86532559E-02	ZS= 3.22848621E 00
T=0.12499958	SBN= 2.68290704E-04	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 4.89357859E 00	YS= -2.07488281E-02	ZS= 2.81125370E 00
T=0.12499964	SBN= 4.07158470E-04	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 4.17091656E 00	YS= -2.41265199E-02	ZS= 2.39402118E 00
T=0.12499970	SBN= 6.62019300E-04	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 3.44826433E 00	YS= -2.95904630E-02	ZS= 1.97678868E 00
T=0.12499976	SBN= 1.18717553E-03	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 2.72564036E 00	YS= -3.87904117E-02	ZS= 1.55955619E 00
T=0.12499982	SBN= 2.48196992E-03	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 2.00311461E 00	YS= -5.57070446E-02	ZS= 1.14232369E 00
T=0.12499988	SBN= 6.95410436E-03	THETA0= 1.04719754E 00	I= 1.00000000E 03
	XS= 1.28105290E 00	YS= -9.24419498E-02	ZS= 7.25091195E-01
	SBN= 4.91422367E-02	THETA0= 1.04719754E 00	I= 1.00000000E 03

## EXAMPLE 1 (Cont'd)

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T=0.12499994  XS= 5.61293197E-01  YS=-1.74425052E-01  ZS= 3.07858711E-01
                SBN= 0.  THETA0= 1.04719754E 00  I= 1.00000000E 03
MISS          XS= 5.61293197E-01  YS=-1.74425052E-01  ZS= 3.07858711E-01  I= 1.00000000E 03
                THETA0= 1.04719754E 00  EOT= 1.00000000E 00  VOT= 1.39999999E 07  IOT= 0.  SBN= 0.
LAST HIT     XS= 2.32929036E-01  YS=-6.66516113E-01  ZS= 5.61953914E-01  I= 1.00000000E 04
                THETA0= 5.23598766E-01  EOT= 1.00000000E 00  VOT= 1.39999999E 07  IOT= 0.  SBN= 0.
T=0.          XS= 1.74999981E 06  YS= 0.  ZS= 5.21540588E-02
                SBN= 1.02208863E-16  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.01562500  XS= 1.53124981E 06  YS= 3.11595660E-05  ZS= 4.56348008E-02
                SBN= 2.95918840E-16  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.03125000  XS= 1.31249981E 06  YS= 3.81549215E-06  ZS= 3.91155428E-02
                SBN= 3.31610724E-16  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.04687500  XS= 1.09374981E 06  YS=-6.95259756E-05  ZS= 3.25962847E-02
                SBN= 4.46993089E-16  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.06250000  XS= 8.74999809E 05  YS= 3.1372623E-06  ZS= 2.60770267E-02
                SBN= 1.49906297E-16  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.07812500  XS= 6.56249809E 05  YS= 1.15862805E-04  ZS= 1.95577689E-02
                SBN= 6.08709627E-16  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.09375000  XS= 4.37499815E 05  YS= 9.50475836E-05  ZS= 1.30385108E-02
                SBN= 2.45301035E-16  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.10937500  XS= 2.18749818E 05  YS= 1.45454164E-04  ZS= 6.51925296E-03
                SBN= 1.90789075E-15  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.11132813  XS= 1.91406070E 05  YS= 1.61214100E-04  ZS= 5.70434570E-03
                SBN= 4.98389047E-16  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.11328125  XS= 1.64062320E 05  YS= 1.77291985E-04  ZS= 4.88943845E-03
                SBN= 5.08771884E-16  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.11523438  XS= 1.36718570E 05  YS= 1.91886085E-04  ZS= 4.07453120E-03
                SBN= 7.54432333E-15  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.11718750  XS= 1.09374820E 05  YS= 2.44093958E-04  ZS= 3.25962394E-03
                SBN= 6.65033060E-15  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.11914063  XS= 8.20310700E 04  YS= 3.29686779E-04  ZS= 2.44471669E-03
                SBN= 5.08767420E-15  THETA0= 1.57079630E 00  I= 1.00000000E 03
T=0.12109375  XS= 5.46873206E 04  YS= 4.37536156E-04  ZS= 1.62980944E-03

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EXAMPLE 1 (Cont'd)

T=0.12304688	SBN= 2.59469527E-14	THETA0= 1.5707963CE	00	I= 1.0C000000E 03
	XS= 2.73435712E 04	YS= 6.77811277E-04	ZS= 8.14902186E-04	
	SBN= 1.89693928E-14	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12329102	XS= 2.39256024E 04	YS= 7.09358388E-04	ZS= 7.13038784E-04	
	SBN= 3.18957147E-14	THETA0= 1.57079630E	00	I= 1.0C000000E 03
T=0.12353516	XS= 2.05076337E 04	YS= 7.43449038E-04	ZS= 6.11175382E-04	
	SBN= 7.84946513E-15	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12377930	XS= 1.70896649E 04	YS= 7.78072912E-04	ZS= 5.09311774E-04	
	SBN= 4.84908283E-14	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12402344	XS= 1.36716962E 04	YS= 8.16563702E-04	ZS= 4.07448566E-04	
	SBN= 3.66296861E-14	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12426758	XS= 1.02537274E 04	YS= 8.54359090E-04	ZS= 3.05585161E-04	
	SBN= 7.50018156E-14	THETA0= 1.5707963CE	00	I= 1.00000000E 03
T=0.12451172	XS= 6.83575886E 03	YS= 8.97579086E-04	ZS= 2.03721756E-04	
	SBN= 1.56972529E-13	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12475586	XS= 3.41779014E 03	YS= 9.29255116E-04	ZS= 1.01858351E-04	
	SBN= 1.4247392CE-12	THETA0= 1.5707963CE	00	I= 1.00000000E 03
T=0.12478638	XS= 2.99054405E 03	YS= 9.31456757E-04	ZS= 8.91254246E-05	
	SBN= 1.97895662E-12	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12481689	XS= 2.56329796E 03	YS= 9.31207490E-04	ZS= 7.63924986E-05	
	SBN= 3.02007326E-12	THETA0= 1.57079630E	00	I= 1.0C000000E 03
T=0.12484741	XS= 2.13605186E 03	YS= 9.27195156E-04	ZS= 5.36595732E-05	
	SBN= 5.40919536E-12	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12487793	XS= 1.70880578E 03	YS= 9.16456747E-04	ZS= 5.09266472E-05	
	SBN= 1.03694180E-11	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12490845	XS= 1.28155971E 03	YS= 8.92823911E-04	ZS= 3.81937215E-05	
	SBN= 2.60150012E-11	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12493896	XS= 8.54313624E 02	YS= 8.36775875E-04	ZS= 2.54607958E-05	
	SBN= 8.73501182E-11	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12496948	XS= 4.27067554E 02	YS= 6.71905482E-04	ZS= 1.27278700E-05	
	SBN= 6.98259556E-10	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12497330	XS= 3.73661795E 02	YS= 6.37702447E-04	ZS= 1.11362542E-05	
	SBN= 1.04568829E-09	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12497711	XS= 3.20256037E 02	YS= 5.83141285E-04	ZS= 9.54463851E-06	
	SBN= 1.66191210E-09	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12498093	XS= 2.66850281E 02	YS= 4.96225238E-04	ZS= 7.95302284E-06	
	SBN= 2.87537494E-09	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12498474	XS= 2.13444522E 02	YS= 3.53330886E-04	ZS= 6.36140710E-06	
	SBN= 5.61737198E-09	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12498856	XS= 1.60038765E 02	YS= 1.01079486E-04	ZS= 4.76979136E-06	
	SBN= 1.33345401E-08	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499237	XS= 1.06633009E 02	YS=-4.10749012E-04	ZS= 3.17817569E-06	
	SBN= 4.50838649E-08	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499619	XS= 5.32272530E 01	YS=-1.80005731E-03	ZS= 1.58656C01E-06	
	SBN= 3.62636012E-07	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499666	XS= 4.65515333E 01	YS=-2.08390388E-03	ZS= 1.38760805E-06	
	SBN= 5.42190742E-07	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499714	XS= 3.98758137E 01	YS=-2.53242844E-03	ZS= 1.18865608E-06	
	SBN= 8.62858725E-07	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499762	XS= 3.32000944E 01	YS=-3.24287710E-03	ZS= 9.89704108E-07	
	SBN= 1.49568796E-06	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499809	XS= 2.65243751E 01	YS=-4.40691751E-03	ZS= 7.90752149E-07	
	SBN= 2.93551192E-06	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499857	XS= 1.98486562E 01	YS=-6.45964360E-03	ZS= 5.91800183E-07	
	SBN= 7.01755869E-06	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499905	XS= 1.31729379E 01	YS=-1.06287850E-02	ZS= 3.92848223E-07	
	SBN= 2.41266736E-05	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499952	XS= 6.49722415E 00	YS=-2.19950724E-02	ZS= 1.93896264E-07	
	SBN= 2.06427974E-04	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499958	XS= 5.66276145E 00	YS=-2.43217397E-02	ZS= 1.69027272E-07	
	SBN= 3.15022290E-04	THETA0= 1.57079630E	00	I= 1.00000000E 03
T=0.12499964	XS= 4.82830250E 00	YS=-2.79967386E-02	ZS= 1.44158310E-07	

## EXAMPLE 1 (Cont'd)

T=0.12499970	SBN= 5.16075844E-04	THETA0= 1.57079630E 00	I= 1.00000000E 03
	XS= 3.99385294E 00	YS=-3.37965402E-02	ZS= 1.19289342E-07
	SBN= 9.34100628E-04	THETA0= 1.57079630E 00	I= 1.00000000E 03
T=0.12499976	XS= 3.15942842E 00	YS=-4.31999564E-02	ZS= 9.44203615E-08
	SBN= 1.96432231E-03	THETA0= 1.57079630E 00	I= 1.00000000E 03
T=0.12499982	XS= 2.32507950E 00	YS=-5.93126839E-02	ZS= 6.95513314E-08
	SBN= 5.29909277E-03	THETA0= 1.57079630E 00	I= 1.00000000E 03
T=0.12499988	XS= 1.49099770E 00	YS=-8.92563021E-02	ZS= 4.46821874E-08
	SBN= 2.40346363E-02	THETA0= 1.57079630E 00	I= 1.00000000E 03
T=0.12499994	XS= 6.58000022E-01	YS=-1.49397792E-01	ZS= 1.98075867E-08
	SBN= 0.	THETA0= 1.57079630E 00	I= 1.00000000E 03
T=0.	XS= 1.74999981E 06	YS= 0.	ZS= 5.21540588E-02
	SBN= 1.02208862E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.01562500	XS= 1.53124981E 06	YS= 3.11595663E-04	ZS= 4.56348008E-02
	SBN= 2.95918807E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.03125000	XS= 1.31249981E 06	YS= 3.81550997E-05	ZS= 3.91155428E-02
	SBN= 3.31610787E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.04687500	XS= 1.09374981E 06	YS=-6.95259571E-04	ZS= 3.25962847E-02
	SBN= 4.46993113E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.06250000	XS= 8.74999809E 05	YS= 3.13729468E-05	ZS= 2.60770267E-02
	SBN= 1.49906300E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.07812500	XS= 6.56249809E 05	YS= 1.15862836E-03	ZS= 1.95577689E-02
	SBN= 6.08709639E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.09375000	XS= 4.37499815E 05	YS= 9.50476325E-04	ZS= 1.30385108E-02
	SBN= 2.45301035E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.10937500	XS= 2.18749818E 05	YS= 1.45454231E-03	ZS= 6.51925296E-03
	SBN= 1.90789104E-14	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.11132813	XS= 1.91406070E 05	YS= 1.61214171E-03	ZS= 5.70434570E-03
	SBN= 4.98389059E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.11328125	XS= 1.64062320E 05	YS= 1.77292059E-03	ZS= 4.88943845E-03
	SBN= 5.08771902E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.11523438	XS= 1.36718570E 05	YS= 1.91886163E-03	ZS= 4.07453120E-03
	SBN= 7.54432279E-14	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.11718750	XS= 1.09374820E 05	YS= 2.44094038E-03	ZS= 3.25962394E-03
	SBN= 6.65033203E-14	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.11914063	XS= 8.20310712E 04	YS= 3.29686865E-03	ZS= 2.44471669E-03
	SBN= 9.44858956E-15	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12109375	XS= 5.46873218E 04	YS= 4.16392517E-03	ZS= 1.62980944E-03
	SBN= 2.59469515E-13	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12304688	XS= 2.73435733E 04	YS= 6.35523909E-03	ZS= 8.14902186E-04
	SBN= 1.89694035E-13	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12329102	XS= 2.39256045E 04	YS= 6.64428055E-03	ZS= 7.13038784E-04
	SBN= 6.32930660E-13	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12353516	XS= 2.05076358E 04	YS= 6.98379534E-03	ZS= 6.11175382E-04
	SBN= 3.92465180E-13	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12377930	XS= 1.70896675E 04	YS= 7.35460740E-03	ZS= 5.09311474E-04
	SBN= 4.60490274E-13	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12402344	XS= 1.36716989E 04	YS= 7.76214135E-03	ZS= 4.07448566E-04
	SBN= 3.40133703E-13	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12426758	XS= 1.02537304E 04	YS= 8.15924358E-03	ZS= 3.05585161E-04
	SBN= 7.03503561E-13	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12451172	XS= 6.83576202E 03	YS= 8.60224605E-03	ZS= 2.03721756E-04
	SBN= 1.58717568E-12	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12475586	XS= 3.41779357E 03	YS= 8.94789135E-03	ZS= 1.01858351E-04
	SBN= 1.21721484E-11	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12478638	XS= 2.99054751E 03	YS= 8.97623456E-03	ZS= 8.91254246E-05
	SBN= 1.97496831E-11	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12481689	XS= 2.56330144E 03	YS= 8.98011839E-03	ZS= 7.63924986E-05
	SBN= 3.00379226E-11	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12484741	XS= 2.13605538E 03	YS= 8.94657433E-03	ZS= 6.36595732E-05
	SBN= 5.41197735E-11	THETA0= 1.57079630E 00	I= 1.00000000E 04
T=0.12487793	XS= 1.70880933E 03	YS= 8.84566545E-03	ZS= 5.09266472E-05

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## EXAMPLE 1 (Cont'd)

T=0.12490845	SBN= 1.07843257E-10	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 1.28156328E 03	YS= 8.61038160E-03	ZS= 3.81937215E-05
T=0.12493896	SBN= 2.55315402E-10	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 8.54317224E 02	YS= 8.05696988E-03	ZS= 2.54607958E-05
T=0.12496948	SBN= 8.73393500E-10	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 4.27071190E 02	YS= 6.41546893E-03	ZS= 1.27278705E-05
T=0.12497330	SBN= 6.99012607E-09	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 3.73665431E 02	YS= 6.07419235E-03	ZS= 1.11362547E-05
T=0.12497711	SBN= 1.04493083E-08	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 3.20259675E 02	YS= 5.52948195E-03	ZS= 9.54463899E-06
T=0.12498093	SBN= 1.66175392E-08	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 2.66853923E 02	YS= 4.66125363E-03	ZS= 7.95302331E-06
T=0.12498474	SBN= 2.87490231E-08	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 2.13448170E 02	YS= 3.23333421E-03	ZS= 6.36140764E-06
T=0.12498856	SBN= 5.61862397E-08	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 1.60042416E 02	YS= 7.11600554E-04	ZS= 4.76979196E-06
T=0.12499237	SBN= 1.33329423E-07	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 1.06636663E 02	YS= -4.40559286E-03	ZS= 3.17817631E-06
T=0.12499619	SBN= 4.50742638E-07	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 5.32309115E 01	YS= -1.82957143E-02	ZS= 1.58656064E-06
T=0.12499666	SBN= 3.62552974E-06	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 4.65551931E 01	YS= -2.11335579E-02	ZS= 1.38760866E-06
T=0.12499714	SBN= 5.42051876E-06	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 3.98794749E 01	YS= -2.56177592E-02	ZS= 1.18865670E-06
T=0.12499762	SBN= 8.62614298E-06	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 3.32037583E 01	YS= -3.27204600E-02	ZS= 9.89704740E-07
T=0.12499809	SBN= 1.49519105E-05	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 2.65280470E 01	YS= -4.43575722E-02	ZS= 7.90752780E-07
T=0.12499857	SBN= 2.93426803E-05	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 1.98523512E 01	YS= -6.48777771E-02	ZS= 5.9180839E-07
T=0.12499905	SBN= 7.01351798E-05	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 1.31767204E 01	YS= -1.06549945E-01	ZS= 3.92849091E-07
T=0.12499952	SBN= 2.41034585E-04	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 6.50153875E 00	YS= -2.20124274E-01	ZS= 1.93897299E-07
T=0.12499958	SBN= 2.05650291E-03	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 5.66729456E 00	YS= -2.43346789E-01	ZS= 1.69028318E-07
T=0.12499964	SBN= 3.13363335E-03	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 4.83342379E 00	YS= -2.79982856E-01	ZS= 1.44159023E-07
T=0.12499970	SBN= 5.11732405E-03	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 4.00047874E 00	YS= -3.37689447E-01	ZS= 1.19289559E-07
T=0.12499976	SBN= 9.19026136E-03	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 3.16999075E 00	YS= -4.30861503E-01	ZS= 9.44185030E-08
T=0.12499982	SBN= 1.88796706E-02	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 2.34676042E 00	YS= -5.88724524E-01	ZS= 6.95428991E-08
T=0.12499988	SBN= 4.65634876E-02	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 1.54755762E 00	YS= -8.71887183E-01	ZS= 4.46345538E-08
T=0.12499994	SBN= 1.26268327E-01	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 8.27708101E-01	YS= -1.37901781E 00	ZS= 1.93187554E-08
T=0.12499995	SBN= 1.80657470E-01	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 7.40319878E-01	YS= -1.44608973E 00	ZS= 1.61451855E-08
T=0.12499996	SBN= 1.74057561E-01	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 6.55635226E-01	YS= -1.51668414E 00	ZS= 1.29497878E-08
T=0.12499996	SBN= 1.63562746E-01	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 5.73725176E-01	YS= -1.59060696E 00	ZS= 9.71073437E-09
T=0.12499997	SBN= 1.50435190E-01	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 4.94619358E-01	YS= -1.66763699E 00	ZS= 6.43166322E-09
T=0.12499998	SBN= 1.35967377E-01	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 4.18306756E-01	YS= -1.74753551E 00	ZS= 3.13804016E-09
T=0.12499999	SBN= 1.21252009E-01	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 3.44739011E-01	YS= -1.83005570E 00	ZS= -1.91962723E-10
T=0.12499999	SBN= 1.11180331E-01	THETA0= 1.57079630E 00	I= 1.00000000E 04
	XS= 2.73784667E-01	YS= -1.91490576E 00	ZS= -3.52264771E-09



## EXAMPLE 1 (Cont'd)

```

I=0.12500000  SBN= 9.77390528E-02  THETA= 1.57079630E 00  I= 1.00000000E 04
                XS= 2.05347979E-01  YS=-2.00186116E 00  ZS=-6.85628855E-09
SBN= 8.55832720E-02  THETA= 1.57079630E 00  I= 1.00000000E 04
                XS= 1.39314283E-01  YS=-2.09070778E 00  ZS=-1.01928852E-08
I=0.12500001  SBN= 7.47924387E-02  THETA= 1.57079630E 00  I= 1.00000000E 04
                XS= 7.55558354E-02  YS=-2.18124545E 00  ZS=-1.35331199E-08
I=0.12500002  SBN= 6.53358436E-02  THETA= 1.57079630E 00  I= 1.00000000E 04
                XS= 1.39371775E-02  YS=-2.27328998E 00  ZS=-1.68756281E-08
I=0.12500003  SBN= 5.71198028E-02  THETA= 1.57079630E 00  I= 1.00000000E 04
                XS=-4.56802171E-02  YS=-2.36667424E 00  ZS=-2.02222224E-08
I=0.12500004  SBN= 5.00203794E-02  THETA= 1.57079630E 00  I= 1.00000000E 04
                XS=-1.03434198E-01  YS=-2.46124813E 00  ZS=-2.35729224E-08
MISS          SBN= 4.39045733E-02  THETA= 1.57079630E 00  I= 1.00000000E 04
                XS=-1.03434198E-01  YS=-2.46124813E 00  ZS=-2.35729224E-08  I= 1.00000000E 04
THETA= 1.57079630E 00  ECI= 1.00000000E 00  VOT= 1.39999999E 07  ICI= 0.          SRV= 4.
LAST HIT      XS= 6.58000022E-01  YS=-1.49397792E-01  ZS= 1.98075867E-08  I= 1.00000000E 03
THETA= 1.57079630E 00  EOI= 1.00000000E 00  VOT= 1.39999999E 07  ICI= 0.          SRV= 0.

```

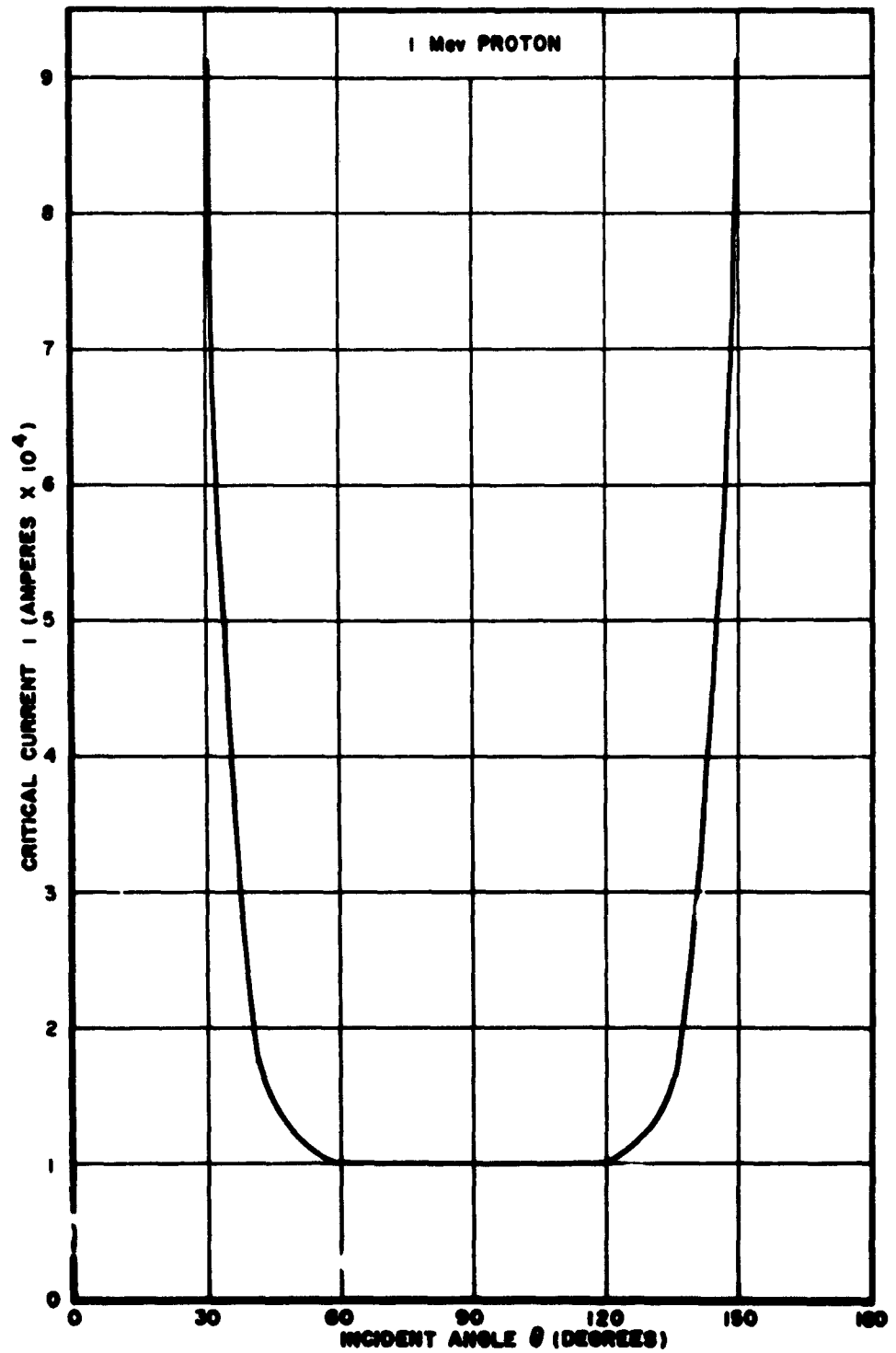


Figure II-1. Deflection Current Versus Particle Incident Angle ( $E$ )

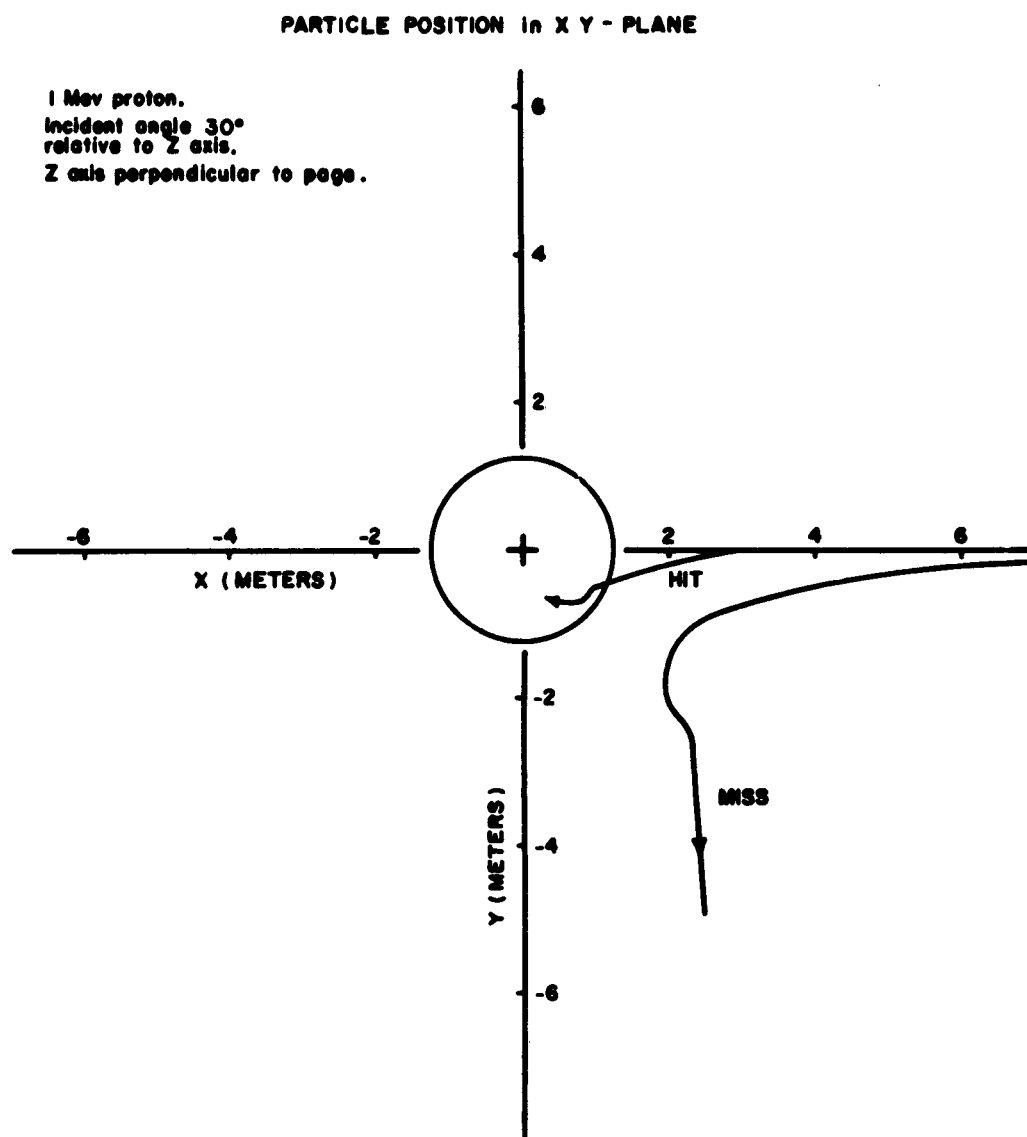


Figure II-2. Particle Trajectories

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**APPENDIX III**  
**DATA FROM EXAMPLE 2 PROBLEM**

## EXAMPLE 2

CHARGED PARTICLE SHIELDING

IAT=0 INDICATES A FIELD PLOT

IAT=1 INDICATES A TRAJECTORY

JAT=0 INDICATES A PLOT OF TRAJECTORY

JAT=1 INDICATES NO PLOT OF TRAJECTORY

JAT=2 INDICATES MULTIPLE CURVE VALUES

LAT=0 INDICATES DUMP MISS AND LAST HIT

LAT=1 INDICATES NO DUMP MISS AND LAST HIT

LAT=2 MULTIPLE CURVE FIELD PLOT

SMAX= 3 HMAX= 3 MMAX= 0 IMAX= 2 IAT= 1 JAT= 2 LAT= 0  
 ACHX=7.199999E 01 AAAA=5.000000E 00 B98B=2.000000E 03 MO=1.6724300E-27  
 DTETA0=3.000000E 01 DTHETA=0. RMAX=0.

ZHMAX= -5.1000000E 01 4.9999999E 01 7.1999999E 01  
 ZHMIN= -7.1999999E 01 -4.9999999E 01 5.1000000E 01

CZH= 1.0000000E 00 1.0000000E 00 1.0000000E 00

DADZ= 2.0000000E 00 0. -2.0000000E 00

AHMAX= 4.8000000E 01 4.8000000E 01 4.8000000E 01

AHMIN= 4.0000000E 00 4.8000000E 01 4.0000000E 00

LOT= 1.2500E 02 5.0000E 02

VOT= 1.4090E 08 2.2630E 08

LOT= 1.4000E 04 2.0000E 04

MISS XS=-0.

THETA0= 0. EUT= 1.25000000E 02 VOT= 1.43507482E 00 I= 7.19999999E 04

LAST HIT XS=-0. YS=-0. ZS= 1.40899999E 08 IOT= 0. SBN= 0.

THETA0= 0. EUT= 1.25000000E 02 VOT= 1.43507482E 00 I= 1.39999999E 04

LAST HIT XS= 4.16630256E 00 YS=-0. ZS= 1.40899999E 08 IOT= 0. SBN= 0.

THETA0= 5.23598766E-01 EUT= 1.25000000E 02 VOT= 1.40899999E 08 IOT= 0. SBN= 0.

LAST HIT XS= 5.81735254E-01 YS= 1.65819259E-02 VOT= 1.40899999E 08 IOT= 0. SBN= 4.98190862E-03

THETA0= 5.23598766E-01 EUT= 1.25000000E 02 VOT= 1.40899999E 08 IOT= 0. SBN= 0.

MISS XS= 1.19067320E 01 YS=-8.68629980E 00 ZS=-3.62446657E 00 I= 3.61999997E 05

THETA0= 1.04719754E 00 EUT= 1.25000000E 02 VOT= 1.40899999E 08 IOT= 0. SBN= 6.14792836E-03

LAST HIT XS= 6.70593530E-01 YS=-6.56782568E-01 ZS= 4.97871113E-02 I= 7.19999999E 04

THETA0= 1.04719754E 00 EUT= 1.25000000E 02 VOT= 1.40899999E 08 IOT= 0. SBN= 0.

MISS XS= 9.62272561E 00 YS=-1.08969179E 01 ZS=-2.24065146E-07 I= 3.61999997E 05

THETA0= 1.57079630E 00 EUT= 1.25000000E 02 VOT= 1.40899999E 08 IOT= 0. SBN= 0.

LAST HIT XS= 7.75122106E-01 YS=-3.73479789E-01 ZS= 1.43072111E-08 I= 7.19999999E 04

THETA0= 1.57079630E 00 EUT= 1.25000000E 02 VOT= 1.40899999E 08 IOT= 0. SBN= 0.

MISS XS= 5.81030357E-01 YS=-7.93675286E-01 ZS=-4.97871113E-02 I= 7.19999999E 04

THETA0= 2.09439507E 00 EUT= 1.25000000E 02 VOT= 1.40899999E 08 IOT= 0. SBN= 0.

LAST HIT XS= 9.61739612E-01 YS=-4.77032584E-02 ZS=-5.74680310E-01 I= 1.39999999E 04

THETA0= 2.09439507E 00 EUT= 1.25000000E 02 VOT= 1.40899999E 08 IOT= 0. SBN= 0.

MISS XS= 4.94958389E 00 YS=-9.53463103E 00 ZS= 6.09928101E 00 I= 7.19999999E 04

THETA0= 2.61799383E 00 EUT= 1.25000000E 02 VOT= 1.40899999E 08 IOT= 0. SBN= 2.75479561E-03

LAST HIT XS= 8.32798684E-01 YS= 2.21266302E-02 ZS=-1.17385460E 00 I= 1.39999999E 04

## EXAMPLE 2 (CONTINUED)

THETA0= 2.61799383E 00	LUT= 1.25000000E 02	VOT= 1.40899999E 08	LOT= 0.	SBN= 0.
MISS	XS= 4.94958389E 00	YS=-9.53403103E 00	ZS= 6.09928101E 00	LOT= 0.
THETA0= 3.14159259E 00	EOT= 1.25000000E 02	VOT= 1.40899999E 08	LOT= 0.	SBN= 0.
LAST HIT	XS= 8.32798684E-01	YS= 2.21266302E-02	ZS=-1.17365460E 00	LOT= 0.
THETA0= 2.61799383E 00	EOT= 1.25000000E 02	VOT= 1.40899999E 08	LOT= 0.	SBN= 0.
MISS	XS=-0.	YS=-0.	ZS= 6.57847059E-01	LOT= 0.
THETA0= 0.	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 0.
LAST HIT	XS=-0.	YS=-0.	ZS= 6.57847059E-01	LOT= 0.
THETA0= 0.	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 0.
MISS	XS=-5.85257065E 00	YS= 3.92630765E 00	ZS=-9.76516712E 00	LOT= 0.
THETA0= 5.23598766E-01	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 2.77845627E-02
LAST HIT	XS= 6.43357307E-01	YS= 4.17717654E-01	ZS= 4.56067097E-01	LOT= 0.
THETA0= 5.23598766E-01	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 0.
MISS	XS= 1.03493646E 01	YS=-2.00413007E 01	ZS=-5.96516544E 00	LOT= 0.
THETA0= 1.04719754E 00	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 2.41340712E-03
LAST HIT	XS= 3.35827857E-01	YS=-5.62319016E-01	ZS=-6.39331710E-02	LOT= 0.
THETA0= 1.04719754E 00	LUT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 0.
MISS	XS=-9.77937746E 00	YS= 8.59896183E 00	ZS=-3.31820661E-07	LOT= 0.
THETA0= 1.57079630E 00	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 6.39969063E-02
LAST HIT	XS= 5.13952297E-01	YS=-7.84486234E-01	ZS=-3.09057521E-08	LOT= 0.
THETA0= 1.57079630E 00	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 0.
MISS	XS= 8.71539736E 00	YS=-2.06630242E 01	ZS= 5.75087959E 00	LOT= 0.
THETA0= 2.09439507E 00	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 2.45932573E-03
LAST HIT	XS= 4.93456852E-01	YS=-3.67215520E-01	ZS=-1.50352009E-01	LOT= 0.
THETA0= 2.09439507E 00	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 0.
MISS	XS=-1.45993993E 01	YS= 7.16600883E 00	ZS= 1.01937376E 01	LOT= 0.
THETA0= 2.61799383E 00	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 5.36509625E-03
LAST HIT	XS= 8.87609923E-01	YS=-1.5316887E-02	ZS=-2.74956077E-02	LOT= 0.
THETA0= 2.61799383E 00	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 0.
MISS	XS=-1.45993993E 01	YS= 7.16600883E 00	ZS= 1.01937376E 01	LOT= 0.
THETA0= 3.14159259E 00	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 0.
LAST HIT	XS= 8.87609923E-01	YS=-1.5316887E-02	ZS=-2.74956077E-02	LOT= 0.
THETA0= 2.61799383E 00	EOT= 5.00000000E 02	VOT= 2.26299998E 08	LOT= 0.	SBN= 0.

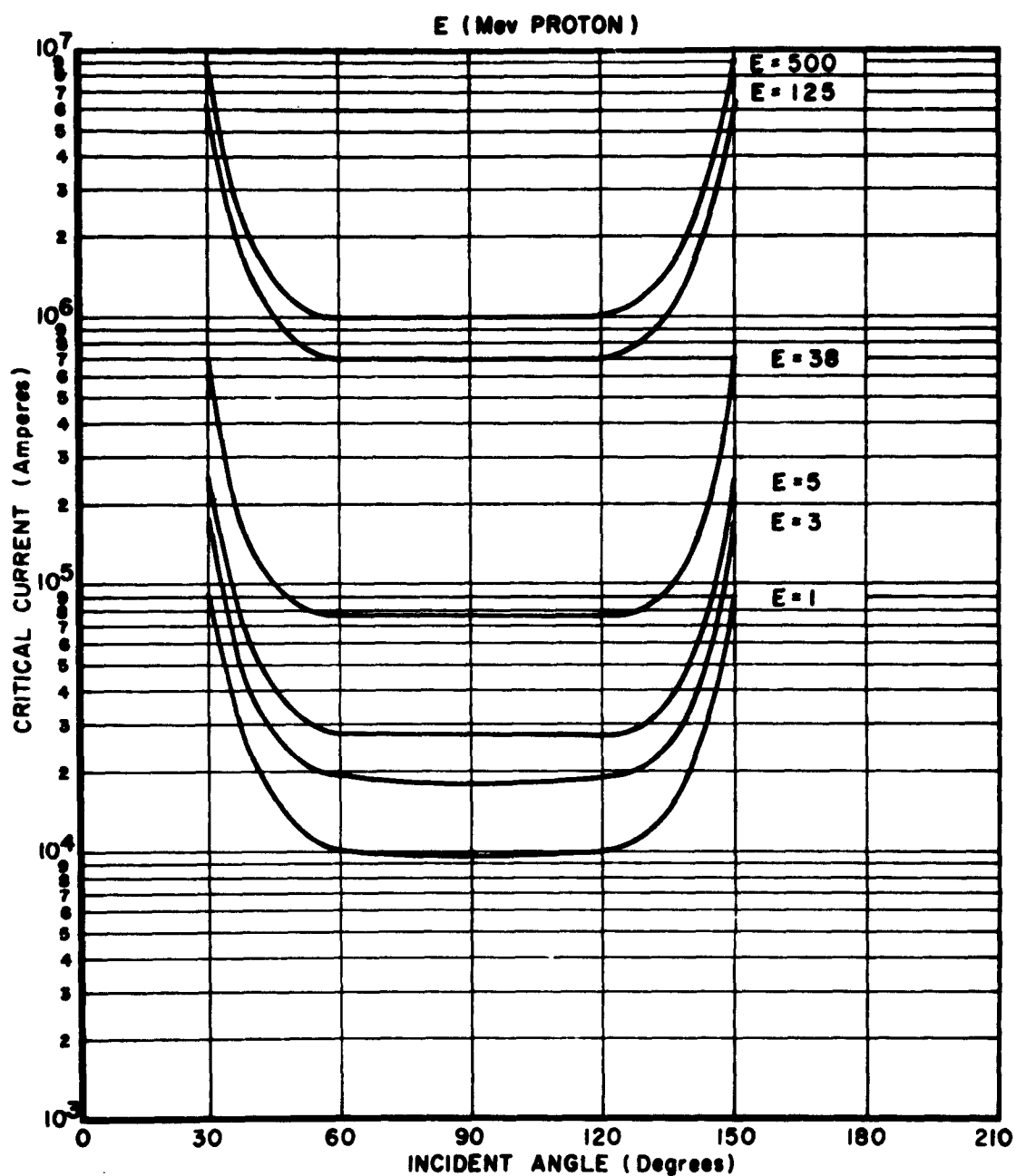


Figure III-1. Deflection Current for Six Different Energy Particles Versus Incident Angle

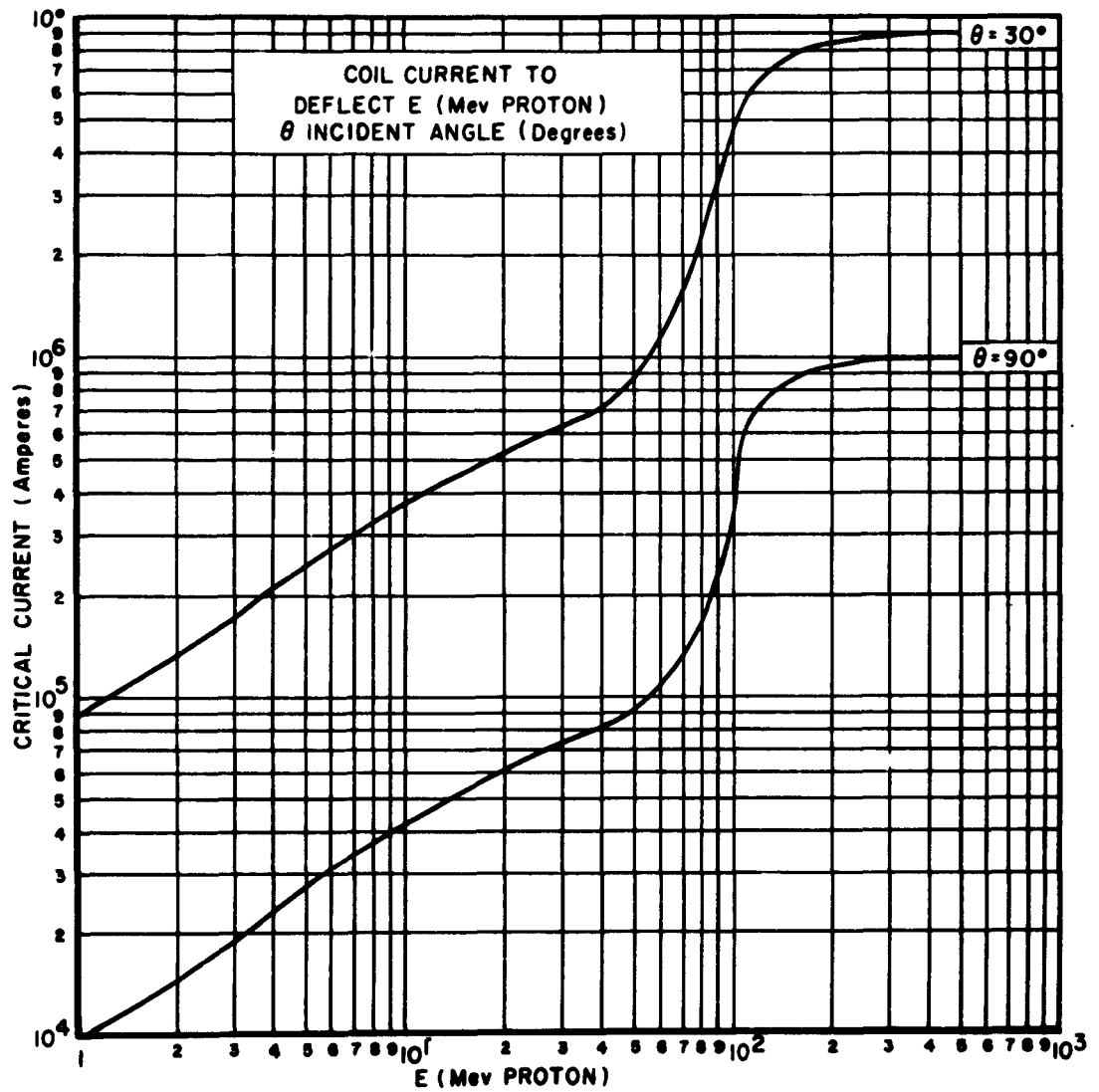


Figure III-2. Particle Energy Versus Loop Current



**APPENDIX IV**  
**DATA FROM EXAMPLES 3 AND 4 PROBLEMS**

# 72 EXAMPLE 3

CHARGED PARTICLE SHIELDING  
 IAT=0 INDICATES A FIELD PLOT  
 IAT=1 INDICATES A TRAJECTORY  
 JAT=0 INDICATES A PLOT OF TRAJECTORY  
 JAT=1 INDICATES NO PLOT OF TRAJECTORY  
 JAT=2 INDICATES MULTIPLE CURNT VALUES  
 LAT=0 INDICATES DUMP MISS AND LAST HIT  
 LAT=1 INDICATES NO DUMP MISS AND LAST HIT  
 LAT=2 MULTIPLE CURNT FIELD PLOT  
 SHAX= 21 HMAX= 3 MMAX= 7 IMAX= 1 IAT= 0 JAT= 1 LAT= 1  
 AGMX=0. AAAA=0. DR=7.0000000E 00 RMAX=1.4000000E 02

DTETA0=0. DTHETA=1.5000000E 01 RBBB=0. MO=0.  
 ZHMAX= -5.1000000E 01 4.9999999E 01 7.1999999E 01  
 ZHMIN= -7.1999999E 01 -4.9999999E 01 5.1000000E 01  
 DZH= 1.0000000E 00 1.0000000E 00 1.0000000E 00  
 DA/DZ= 2.0000000E 00 0. -2.0000000E 00  
 AHMAX= 4.8000000E 01 4.8000000E 01 4.8000000E 01  
 AHMIN= 4.0000000E 00 4.8000000E 01 4.0000000E 00  
 EOT= 5.0000E 02  
 VDT=-0.

LOT= 9.0000E 06

THETA RHO, ZS

0.	0.	3.55000697E 00	2.61909682E 01	2.61909688E 01
0.	0.	3.37820661E 00	3.10547388E 01	3.10547391E 01
0.	0.	3.20040625E 00	3.72196060E 01	3.72196060E 01
0.	0.	3.02260590E 00	4.51613188E 01	4.51613188E 01
0.	0.	2.84480557E 00	5.55932993E 01	5.55933005E 01
0.	0.	2.66700521E 00	6.96397394E 01	6.96397394E 01
0.	0.	2.48920485E 00	8.92146826E 01	8.92146826E 01
0.	0.	2.31140453E 00	1.18042091E 02	1.18042092E 02
0.	0.	2.13360417E 00	1.65469746E 02	1.65469746E 02
0.	0.	1.95580384E 00	2.70909643E 02	2.70909643E 02
0.	0.	1.77800348E 00	3.83101431E 02	3.83101436E 02
0.	0.	1.60020314E 00	3.35721070E 02	3.35721070E 02
0.	0.	1.42240278E 00	3.16812530E 02	3.16812533E 02
0.	0.	1.24460246E 00	3.12469992E 02	3.12469992E 02
0.	0.	1.06680210E 00	3.15923724E 02	3.15923724E 02
0.	0.	8.89001739E-01	3.23137572E 02	3.23137572E 02
0.	0.	7.11201388E-01	3.31373787E 02	3.31373787E 02
0.	0.	5.33401060E-01	3.38871691E 02	3.38871691E 02
0.	0.	3.55600709E-01	3.44627032E 02	3.44627032E 02
0.	0.	1.77800354E-01	3.48142645E 02	3.48142651E 02
0.	-0.	-0.	3.49212557E 02	3.49212560E 02
0.2618	9.20362318E-01	3.43483895E 00	2.51696688E 01	2.27107674E 01

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EXAMPLE 3 (Cont'd)

0.2616	8.74344206E-01	3.26309702E 00	2.98182094E 01	1.25704305E 01	2.68441713E 01
0.2618	8.28326082E-01	3.09135506E 00	3.57013690E 01	1.51504017E 01	3.20530036E 01
0.2618	7.82307971E-01	2.91961309E 00	4.32614396E 01	1.84911731E 01	3.87088835E 01
0.2618	7.36289859E-01	2.74787116E 00	5.31471598E 01	2.28965291E 01	4.73434037E 01
0.2618	6.90271741E-01	2.57612920E 00	6.63384467E 01	2.88322553E 01	5.87260973E 01
0.2618	6.44253623E-01	2.40438727E 00	8.43726170E 01	3.70436755E 01	7.39737684E 01
0.2618	5.98235506E-01	2.23264533E 00	1.09796980E 02	4.87847525E 01	9.46711445E 01
0.2618	5.52217394E-01	2.0690337E 00	1.47262390E 02	6.62498391E 01	1.22868733E 02
0.2618	5.06194276E-01	1.88916144E 00	2.07589751E 02	9.31420660E 01	1.60515337E 02
0.2618	4.60181159E-01	1.71741948E 00	3.55637333E 02	1.35350032E 02	2.10658544E 02
0.2618	4.14163047E-01	1.54567754E 00	3.39617279E 02	-1.65852560E 01	3.03607893E 02
0.2618	3.68144929E-01	1.37393558E 00	3.17588180E 02	-3.39592832E 00	3.02970800E 02
0.2618	3.22126821E-01	1.20219366E 00	3.15124866E 02	3.41559851E 00	3.07665262E 02
0.2618	2.76108700E-01	1.03045170E 00	3.19631729E 02	5.80174500E 00	3.15480539E 02
0.2618	2.30090582E-01	8.58709741E-01	3.26713685E 02	5.59430218E 00	3.24327213E 02
0.2618	1.84072465E-01	6.86967790E-01	3.34107840E 02	4.20830446E 00	3.32742658E 02
0.2618	1.38054353E-01	5.15225863E-01	3.40551757E 02	2.56431848E 00	3.39833418E 02
0.2618	9.20362333E-02	3.43483910E-01	3.45406654E 02	1.17573541E 00	3.45094472E 02
0.2618	4.60181177E-02	1.71741955E-01	3.48338416E 02	2.88339207E-01	3.48261207E 02
0.2618	-0.	-0.	3.49212557E 02	0.	3.49212560E 02
0.5236	1.77800350E 00	3.07959235E 00	2.24032065E 01	1.69434507E 01	1.39282049E 01
0.5236	1.68910332E 00	2.92561272E 00	2.64925143E 01	2.00927120E 01	1.62490578E 01
0.5236	1.60020314E 00	2.77163309E 00	3.166395020E 01	2.40830570E 01	1.92296387E 01
0.5236	1.51130296E 00	2.61765349E 00	3.83334234E 01	2.92147422E 01	2.29400900E 01
0.5236	1.42240280E 00	2.46367389E 00	4.70803511E 01	3.59228951E 01	2.77076820E 01
0.5236	1.33350262E 00	2.30969426E 00	5.88321453E 01	4.48475504E 01	3.39696929E 01
0.5236	1.24460244E 00	2.15571463E 00	7.50780547E 01	5.69361037E 01	4.24325067E 01
0.5236	1.15570228E 00	2.00173503E 00	9.83628106E 01	7.35637087E 01	5.43147218E 01
0.5236	1.06680210E 00	1.84775542E 00	1.33391640E 02	9.65290701E 01	7.18481487E 01
0.5236	9.77901924E-01	1.69377580E 00	1.90280557E 02	1.27278192E 02	9.90330052E 01
0.5236	8.89001739E-01	1.53979617E 00	3.08279747E 02	1.64162715E 02	1.40869975E 02
0.5236	8.00101578E-01	1.38581656E 00	3.48428401E 02	1.10996138E 01	2.64973098E 02
0.5236	7.11201400E-01	1.23183694E 00	3.28866705E 02	1.85981324E 01	2.84013193E 02
0.5236	6.22301233E-01	1.07785735E 00	3.29993188E 02	1.87260737E 01	3.06294599E 02
0.5236	5.33401034E-01	9.23877716E-01	3.34153408E 02	1.57603350E 01	3.19756585E 02
0.5236	4.44500875E-01	7.69846093E-01	3.38467294E 02	1.18344678E 01	3.29698095E 02
0.5236	3.55600700E-01	6.15918469E-01	3.42265734E 02	7.93988800E 00	3.37124553E 02
0.5236	2.66700536E-01	4.61938870E-01	3.45315382E 02	4.584260489E 02	3.42600489E 02
0.5236	1.77800357E-01	3.07959247E-01	3.47564363E 02	2.05025887E 00	3.46388495E 02
0.5236	8.89001787E-02	1.53979623E-01	3.48873663E 02	4.95906347E-01	3.48584723E 02
0.5236	-0.	-0.	3.49212557E 02	0.	3.49212560E 02
0.7854	2.51447666E 00	2.51447660E 00	1.86556150E 01	1.72622696E 01	3.68812531E 00
0.7854	2.38875276E 00	2.38875276E 00	2.19830841E 01	2.02493128E 01	4.07341433E 00

## 74 EXAMPLE 3 (Cont'd)

0.7854	2.26302898E 00	2.26302892E 00	2.61857957E 01	2.39809412E 01	4.47289461E 00
0.7854	2.13730514E 00	2.13730508E 00	3.15910655E 01	2.87123549F 01	4.65661656E 00
0.7854	2.01158133E 00	2.01158127E 00	3.86996821E 01	3.48180029E 01	5.16125351E 00
0.7854	1.88585749E 00	1.88585745E 00	4.8182210E 01	4.28693938E 01	5.25403404E 00
0.7854	1.76013365E 00	1.76013361E 00	6.18402427E 01	5.37875760E 01	4.84710211E 00
0.7854	1.63440980E 00	1.63440980E 00	8.19328666E 01	6.91813117E 01	3.26312301E 00
0.7854	1.50868599E 00	1.50868596E 00	1.14613648E 02	9.22481024E 01	-1.37789220E 00
0.7854	1.38296217E 00	1.38296214E 00	1.78550641E 02	1.30882142E 02	-1.65965894E 01
0.7854	1.25723833E 00	1.25723830E 00	4.18743902E 02	1.74806263E 02	-1.08852309E 02
0.7854	1.13151450E 00	1.13151447E 00	4.58582538E 02	8.50363421E 01	3.06085962E 02
0.7854	1.00579067E 00	1.00579064E 00	3.98918617E 02	5.20215994E 01	3.19271204E 02
0.7854	8.8006848E-01	8.8006824E-01	3.77069420E 02	3.47702637E 01	3.28989914E 02
0.7854	7.54343009E-01	7.54342991E-01	3.65786433E 02	2.36466542E 01	3.35867861E 02
0.7854	6.28619170E-01	6.28619152E-01	3.59126368E 02	1.57241426E 01	3.40764076E 02
0.7854	5.02895331E-01	5.02895314E-01	3.54942352E 02	9.82537842E 00	3.44234198E 02
0.7854	3.77171516E-01	3.77171504E-01	3.52259349E 02	5.44279695E 00	3.46634388E 02
0.7854	2.51447678E-01	2.51447669E-01	3.50572754E 02	2.37501836E 00	3.48187494E 02
0.7854	1.25723839E-01	1.25723834E-01	3.49604675E 02	5.62660664E-01	3.49024549E 02
0.7854	-0.	-0.	3.49212557E 02	0.	3.49212560E 02
1.0472	3.07959238E 00	1.77800344E 00	1.51347432E 01	1.27630109E 01	4.09977198E 00
1.0472	2.92561275E 00	1.68910326E 00	1.77781783E 01	1.46910389E 01	-4.95325029E 00
1.0472	2.77163312E 00	1.60020308E 00	2.10962969E 01	1.70036104E 01	-6.06263882E 00
1.0472	2.61765349E 00	1.51130290E 00	2.53294861E 01	1.97882853E 01	-7.53038859E 00
1.0472	2.46367389E 00	1.42240275E 00	3.08350047E 01	2.31468311E 01	-9.51052177E 00
1.0472	2.30969426E 00	1.33350258E 00	3.81633407E 01	2.71847636E 01	-1.22388038E 01
1.0472	2.15571466E 00	1.24460240E 00	4.82001650E 01	3.19759768E 01	-1.60792993E 01
1.0472	2.00173506E 00	1.15570223E 00	6.24456847E 01	3.74637219E 01	-2.15842602E 01
1.0472	1.84775543E 00	1.06680205E 00	8.35979640E 01	4.32169116E 01	-2.95144531E 01
1.0472	1.69377582E 00	9.7790188E-01	1.16851147E 02	4.79710793E 01	-4.05819756F 01
1.0472	1.53979619E 00	8.89001715E-01	1.73171538E 02	4.93801296E 01	-5.44119442E 01
1.0472	1.38581657E 00	8.00101542E-01	2.81463775E 02	4.55637610E 01	-6.83061498E 01
1.0472	1.23183694E 00	7.11201376E-01	7.18569440E 02	3.77081954E 01	-9.92228866E 01
1.0472	1.07785735E 00	6.22301209E-01	4.72405100E 02	2.87717295E 01	3.59753332E 02
1.0472	9.23877728E-01	5.33401030E-01	4.11998403E 02	2.06490278E 01	3.55868939E 02
1.0472	7.69898094E-01	4.44500864E-01	3.84725901E 02	1.39392838E 01	3.53520277E 02
1.0472	6.15918469E-01	3.55600688E-01	3.69194603E 02	8.67453682E 00	3.51962969E 02
1.0472	4.61938876E-01	2.66700524E-01	3.59588474E 02	4.74264013E 00	3.50834173E 02
1.0472	3.07959250E-01	1.77800351E-01	3.53639412E 02	2.63226697E 00	3.50004566E 02
1.0472	1.53779625E-01	8.89001751E-02	3.50331366E 02	4.65831834E-01	3.49457783E 02
1.0472	-0.	-0.	3.49212557E 02	0.	3.49212560E 02
1.3090	3.43483895E 00	9.20362329E-01	1.28792314E 01	6.43353999E 00	-8.17977452E 00
1.3090	3.26309702E 00	8.74344218E-01	1.51405081E 01	7.26532684E 00	-9.45783246E 00
1.3090	3.09135506E 00	8.28326094E-01	1.797373764E 01	8.26926613E 00	-1.10063425E 01

EXAMPLE 3 (Cont'd)

1.3040	2.41461309L 00	7.82307982E-01	2.15726545E 01	9.40071559E 00	-1.28956266E 01
1.3040	2.74787116L 00	7.3628981E-01	2.62186247E 01	1.06899288E 01	-1.52156648E 01
1.3040	2.57612920L 00	6.90271747E-01	3.23281676E 01	1.21346693E 01	-1.80798510E 01
1.3040	2.40438727E 00	6.44253629E-01	4.05361605E 01	1.37072554E 01	-2.16263589E 01
1.3040	2.23264533L 00	5.98235524E-01	5.18435699E 01	1.53338790E 01	-2.60119855E 01
1.3090	2.06090337E 00	5.52217400E-01	6.78958160E 01	1.68668912E 01	-3.13888177E 01
1.3090	1.83916144E 00	5.06199282E-01	9.15532935E 01	1.80608855E 01	-3.78499734E 01
1.3040	1.71741948E 00	4.60181165E-01	1.28233400E 02	1.85840276E 01	-4.53391039E 01
1.3090	1.54567754L 00	4.14163053E-01	1.89905739E 02	1.81105675E 01	-5.35588763E 01
1.3090	1.37393558E 00	3.68144935E-01	3.13767815E 02	1.64944044E 01	-6.19829261E 01
1.3040	1.20219366E 00	3.22126824E-01	7.23276848E 02	7.90235221E 00	3.72597131E 02
1.3090	1.03045170E 00	2.76108703E-01	4.59017080E 02	1.07804129E 01	3.68340984E 02
1.3040	8.58709741E-01	2.30090585E-01	4.06566501E 02	7.62483436E 00	3.62376726E 02
1.3040	6.86967790E-01	1.84072468E-01	3.80491668E 02	4.83357084E 00	3.57579908E 02
1.3090	5.15225863E-01	1.48054356E-01	3.65153736E 02	2.63036272E 00	3.53711483E 02
1.3090	3.43483910E-01	9.20362377E-02	3.55897105E 02	1.09564273E 00	3.51318245E 02
1.3040	1.71741955E-01	4.60181189E-02	3.50849888E 02	2.27577135E-01	3.49759939E 02
1.3090	-0.	-0.	3.49212557E 02	0.	3.49212560E 02
1.5708	3.55660697L 00	0.	1.21335815E 01	-8.86144888E-02	-9.33544326E 00
1.5708	3.37820661E 00	0.	1.42816618E 01	-1.05107591E-01	-1.06876373E 01
1.5708	3.20040625E 00	0.	1.69701861E 01	-1.25209548E-01	-1.22951241E 01
1.5708	3.02260590E 00	0.	2.03802016E 01	-1.49714518E-01	-1.42138462E 01
1.5708	2.84480557E 00	0.	2.47704339E 01	-1.79514636E-01	-1.65116094E 01
1.5708	2.66700521E 00	0.	3.05191529E 01	-2.15522388E-01	-1.92689957E 01
1.5708	2.48920485E 00	0.	3.81942770E 01	-2.58487394E-01	-2.25785011E 01
1.5708	2.31140453E 00	0.	4.86764514E 01	-3.08656266E-01	-2.65401497E 01
1.5708	2.13360417E 00	0.	6.33882785E 01	-3.65178773E-01	-3.12505943E 01
1.5708	1.95580384E 00	0.	8.47594738E 01	-4.25288391E-01	-3.67822316E 01
1.5708	1.77800348E 00	0.	1.17297924E 02	-4.83448106E-01	-4.31501830E 01
1.5708	1.60020314E 00	0.	1.70600064E 02	-5.3107093E-01	-5.02703816E 01
1.5708	1.42240278E 00	0.	2.71523643E 02	-5.57817054E-01	-5.79278517E 01
1.5708	1.24460246E 00	0.	6.21224827E 02	-5.54852194E-01	-6.6568815E 01
1.5708	1.06680210E 00	0.	4.81492287E 02	-5.18823981E-01	3.72080067E 02
1.5708	8.39001739E-01	0.	4.15205884E 02	-4.53870082E-01	3.65249568E 02

## EXAMPLE 4

CHARGED PARTICLE SHIELDING

IAT=0 INDICATES A FIELD PLOT

IAT=1 INDICATES A TRAJECTORY

JAT=0 INDICATES A PLOT OF TRAJECTORY

JAT=1 INDICATES NO PLOT OF TRAJECTORY

JAT=2 INDICATES MULTIPLE CURNT VALUES

LAT=0 INDICATES DUMP MISS AND LAST HIT

LAT=1 INDICATES NO DUMP MISS AND LAST HIT

LAT=2 MULTIPLE CURNT FIELD PLOT

SMAX= 21 HMAX= 3 MMAX= 7 IMAX= 12 IAT= 0 JAT= 2 LAT= 2  
 AGMX=7.199999E 01 AAAA=7.000000E 00 B88B=2.000000E 03 MO=1.6724300E-27  
 DTETA0=3.000000E 01 DTHETA=1.500000E 01 DR=8.000000E 00 RMAX=1.600000E 02

ZHMAX= -5.100000E 01 4.999999E 01 7.199999E 01  
 ZHMIN= -7.199999E 01 -4.999999E 01 5.100000E 01

DZH= 1.000000E 00 1.000000E 00 1.000000E 00  
 UA/DZ= 2.000000E 00 0. -2.000000E 00

AHMAX= 4.800000E 01 4.800000E 01 4.800000E 01  
 AHMIN= 4.000000E 00 4.800000E 01 4.000000E 00

EOT= 1.0000E 00 1.0000E 00 3.0000E 00 3.0000E 00 5.0000E 00 5.0000E 00 3.8000E 00 3.8000E 00 1.2500E 02  
 EOI= 1.2500E 02 5.0000E 02 5.0000E 02 -0. -0. -0. -0. -0. -0.

VOT=-0. -0. -0. -0. -0. -0. -0. -0. -0. -0.

VOF=-0. -0. -0. -0. -0. -0. -0. -0. -0. -0.

IOT= 1.0000E 04 9.2000E 04 1.9000E 04 1.7500E 05 2.7500E 04 2.5000E 05 7.6000E 04 7.0000E 05 7.0000E 05  
 IOF= 6.4000E 06 1.0000E 06 9.0000E 06

THETA	RHO	ZS	SN	IOT	SPRHO	SRZ
0.	0.	4.0640E	00 1.8785E-02	1.0000E 04 0.	1.8785E-02	1.8785E-02
0.	0.	3.8608E	00 2.2205E-02	1.0000E 04 0.	2.2205E-02	2.2205E-02
0.	0.	3.6576E	00 2.6517E-02	1.0000E 04 0.	2.6517E-02	2.6517E-02
0.	0.	3.4544E	00 3.2036E-02	1.0000E 04 0.	3.2036E-02	3.2036E-02
0.	0.	3.2512E	00 3.9224E-02	1.0000E 04 0.	3.9224E-02	3.9224E-02
0.	0.	3.0480E	00 4.8771E-02	1.0000E 04 0.	4.8771E-02	4.8771E-02
0.	0.	2.8448E	00 6.1770E-02	1.0000E 04 0.	6.1770E-02	6.1770E-02
0.	0.	2.6416E	00 8.0042E-02	1.0000E 04 0.	8.0042E-02	8.0042E-02
0.	0.	2.4384E	00 1.0696E-01	1.0000E 04 0.	1.0696E-01	1.0696E-01
0.	0.	2.2352E	00 1.5011E-01	1.0000E 04 0.	1.5011E-01	1.5011E-01
0.	0.	2.0320E	00 2.3572E-01	1.0000E 04 0.	2.3572E-01	2.3572E-01
0.	0.	1.8288E	00 4.3597E-01	1.0000E 04 0.	4.3597E-01	4.3597E-01
0.	0.	1.6256E	00 3.7813E-01	1.0000E 04 0.	3.7813E-01	3.7813E-01
0.	0.	1.4224E	00 3.5201E-01	1.0000E 04 0.	3.5201E-01	3.5201E-01
0.	0.	1.2192E	00 3.4733E-01	1.0000E 04 0.	3.4733E-01	3.4733E-01
0.	0.	1.0160E	00 3.5305E-01	1.0000E 04 0.	3.5305E-01	3.5305E-01
0.	0.	8.1280E-01	3.6296E-01	1.0000E 04 0.	3.6296E-01	3.6296E-01
0.	0.	6.0960E-01	3.7314E-01	1.0000E 04 0.	3.7314E-01	3.7314E-01
0.	0.	4.0640E-01	3.8133E-01	1.0000E 04 0.	3.8133E-01	3.8133E-01

## EXAMPLE 4 (Cont'd)

0.	0.	2.0320E-01	3.8643E-01	1.0000E	04	0.	3.8643E-01
0.	-0.	-0.	3.8801E-01	1.0000E	04	0.	3.8801E-01
0.2618	1.0518E	00 3.9255E	00 1.8090E-02	1.0000E	04	7.4682E-03	1.6403E-02
0.2618	9.9925E-01	3.7293E	00 2.1366E-02	1.0000E	04	8.8695E-03	1.9340E-02
0.2618	9.4666E-01	3.5330E	00 2.5494E-02	1.0000E	04	1.0648E-02	2.3130E-02
0.2618	8.9407E-01	3.3367E	00 3.0773E-02	1.0000E	04	1.2938E-02	2.7732E-02
0.2618	8.4147E-01	3.1404E	00 3.7635E-02	1.0000E	04	1.5940E-02	3.3818E-02
0.2618	7.8888E-01	2.9441E	00 4.6730E-02	1.0000E	04	1.9952E-02	4.1835E-02
0.2618	7.3629E-01	2.7479E	00 5.9052E-02	1.0000E	04	2.5441E-02	5.2604E-02
0.2618	6.8370E-01	2.5516E	00 7.6192E-02	1.0000E	04	3.3160E-02	6.7374E-02
0.2618	6.3111E-01	2.3553E	00 1.0082E-01	1.0000E	04	4.4405E-02	8.8054E-02
0.2618	5.7851E-01	2.1590E	00 1.3775E-01	1.0000E	04	6.1548E-02	1.1745E-01
0.2618	5.2592E-01	1.9628E	00 1.9736E-01	1.0000E	04	8.9062E-02	1.5905E-01
0.2618	4.7333E-01	1.7665E	00 3.2012E-01	1.0000E	04	1.3430E-01	2.1497E-01
0.2618	4.2074E-01	1.5702E	00 3.8563E-01	1.0000E	04	2.1213E-02	3.3802E-01
0.2618	3.6814E-01	1.3739E	00 3.5288E-01	1.0000E	04	3.7733E-03	3.3663E-01
0.2618	3.1555E-01	1.1777E	00 3.5053E-01	1.0000E	04	4.4240E-03	3.4294E-01
0.2618	2.6296E-01	9.8138E-01	3.5724E-01	1.0000E	04	6.5954E-03	3.5331E-01
0.2618	2.1037E-01	7.8511E-01	3.6660E-01	1.0000E	04	5.6445E-03	3.6450E-01
0.2618	1.5778E-01	5.8883E-01	3.7551E-01	1.0000E	04	3.6221E-03	3.7444E-01
0.2618	1.0518E-01	3.9255E-01	3.8245E-01	1.0000E	04	1.6983E-03	3.8200E-01
0.2618	5.2592E-02	1.9628E-01	3.8672E-01	1.0000E	04	4.2187E-04	3.8660E-01
0.2618-0.	-0.	-0.	3.8801E-01	1.0000E	04	0.	3.8801E-01
0.5236	2.0320E	00 3.5195E	00 1.6190E-02	1.0000E	04	1.2150E-02	1.0314E-02
0.5236	1.9304E	00 3.3436E	00 1.9081E-02	1.0000E	04	1.4362E-02	1.2050E-02
0.5236	1.8288E	00 3.1676E	00 2.2717E-02	1.0000E	04	1.7153E-02	1.4203E-02
0.5236	1.7272E	00 2.9916E	00 2.7361E-02	1.0000E	04	2.0727E-02	1.6907E-02
0.5236	1.6256E	00 2.8156E	00 3.3399E-02	1.0000E	04	2.5380E-02	2.0357E-02
0.5236	1.5240E	00 2.6397E	00 4.1412E-02	1.0000E	04	3.1552E-02	2.4837E-02
0.5236	1.4224E	00 2.4637E	00 5.2312E-02	1.0000E	04	3.9914E-02	3.0786E-02
0.5236	1.3208E	00 2.2877E	00 6.7592E-02	1.0000E	04	5.1504E-02	3.8914E-02
0.5236	1.2192E	00 2.1117E	00 8.9846E-02	1.0000E	04	6.7946E-02	5.0451E-02
0.5236	1.1176E	00 1.9357E	00 1.2393E-01	1.0000E	04	9.1687E-02	6.7725E-02
0.5236	1.0160E	00 1.7598E	00 1.8012E-01	1.0000E	04	1.2571E-01	9.5400E-02
0.5236	9.1440E-01	1.5838E	00 2.8981E-01	1.0000E	04	1.7031E-01	1.4138E-01
0.5236	8.1280E-01	1.4078E	00 3.9803E-01	1.0000E	04	1.0136E-02	2.9061E-01
0.5236	7.1120E-01	1.2318E	00 3.6541E-01	1.0000E	04	2.0665E-02	3.2001E-01
0.5236	6.0960E-01	1.0559E	00 3.6724E-01	1.0000E	04	2.0470E-02	3.4276E-01
0.5236	5.0800E-01	8.7988E-01	3.7268E-01	1.0000E	04	1.6311E-02	3.5878E-01
0.5236	4.0640E-01	7.0391E-01	3.7797E-01	1.0000E	04	1.1250E-02	3.7016E-01
0.5236	3.0480E-01	5.2793E-01	3.8235E-01	1.0000E	04	6.5941E-03	3.7830E-01
0.5236	2.0320E-01	3.5195E-01	3.8558E-01	1.0000E	04	2.9772E-03	3.8386E-01
0.5236	1.0160E-01	1.7598E-01	3.8749E-01	1.0000E	04	7.2701E-04	3.8707E-01
0.5236-0.	-0.	-0.	3.8801E-01	1.0000E	04	0.	3.8801E-01
0.7854	2.8737E	00 2.8737E	00 1.3606E-02	1.0000E	04	1.2697E-02	3.0575E-03
0.7854	2.7300E	00 2.7300E	00 1.5980E-02	1.0000E	04	1.4871E-02	3.4382E-03
0.7854	2.5863E	00 2.5863E	00 1.8954E-02	1.0000E	04	1.7576E-02	3.8665E-03
0.7854	2.4426E	00 2.4426E	00 2.2739E-02	1.0000E	04	2.0989E-02	4.3395E-03
0.7854	2.2990E	00 2.2990E	00 2.7643E-02	1.0000E	04	2.5362E-02	4.8429E-03
0.7854	2.1553E	00 2.1553E	00 3.4143E-02	1.0000E	04	3.1070E-02	5.3385E-03
0.7854	2.0116E	00 2.0116E	00 4.3000E-02	1.0000E	04	3.8687E-02	5.7347E-03
0.7854	1.8679E	00 1.8679E	00 5.5519E-02	1.0000E	04	4.9140E-02	5.8182E-03
0.7854	1.7242E	00 1.7242E	00 7.4156E-02	1.0000E	04	6.4035E-02	5.0687E-03
0.7854	1.5805E	00 1.5805E	00 1.0424E-01	1.0000E	04	8.6488E-02	2.0554E-03
0.7854	1.4368E	00 1.4368E	00 1.6079E-01	1.0000E	04	1.2387E-01	8.4323E-03
0.7854	1.2932E	00 1.2932E	00 3.2976E-01	1.0000E	04	1.9505E-01	6.9782E-02
0.7854	1.1495E	00 1.1495E	00 5.3071E-01	1.0000E	04	1.0307E-01	3.3802E-01
0.7854	1.0058E	00 1.0058E	00 4.4324E-01	1.0000E	04	5.7802E-02	3.5475E-01
0.7854	8.6211E-01	8.6211E-01	4.1669E-01	1.0000E	04	3.6563E-02	3.6680E-01
0.7854	7.1842E-01	7.1842E-01	4.0393E-01	1.0000E	04	2.3474E-02	3.7493E-01
0.7854	5.7474E-01	5.7474E-01	3.9678E-01	1.0000E	04	1.4431E-02	3.8045E-01

## EXAMPLE 4 (Cont'd)

```

0.7854 4.3105E-01 4.3105E-01 3.9252E-01 1.0000E 04 7.9477E-03 3.8413E-01
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0.7854 1.4368E-01 1.4368E-01 3.8856E-01 1.0000E 04 8.2793E-04 3.8772E-01
0.7854-0. -0. 3.8801E-01 1.0000E 04 0. 3.8801E-01
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1.0472 3.3436E 00 1.9304E 00 1.3020E-02 1.0000E 04 1.1280E-02-3.3811E-03
1.0472 3.1676E 00 1.8288E 00 1.5401E-02 1.0000E 04 1.3117E-02-4.1103E-03
1.0472 2.9916E 00 1.7272E 00 1.8415E-02 1.0000E 04 1.5358E-02-5.0675E-03
1.0472 2.8156E 00 1.6256E 00 2.2297E-02 1.0000E 04 1.8110E-02-6.3493E-03
1.0472 2.6397E 00 1.5240E 00 2.7396E-02 1.0000E 04 2.1509E-02-8.1041E-03
1.0472 2.4637E 00 1.4224E 00 3.4261E-02 1.0000E 04 2.5719E-02-1.0567E-02
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1.3090 3.7293E 00 9.9925E-01 1.1057E-02 1.0000E 04 5.8149E-03-7.1854E-03
1.3090 3.5330E 00 9.4666E-01 1.3097E-02 1.0000E 04 6.6664E-03-8.3881E-03
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1.3090 3.1404E 00 8.4147E-01 1.8995E-02 1.0000E 04 8.8597E-03-1.1703E-02
1.3090 2.9441E 00 7.8888E-01 2.3336E-02 1.0000E 04 1.0255E-02-1.4002E-02
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1.3090 2.5516E 00 6.8370E-01 3.7060E-02 1.0000E 04 1.3725E-02-2.0601E-02
1.3090 2.3553E 00 6.3111E-01 4.8216E-02 1.0000E 04 1.5746E-02-2.5319E-02
1.3090 2.1590E 00 5.7851E-01 6.4458E-02 1.0000E 04 1.7794E-02-3.1319E-02
1.3090 1.9628E 00 5.2592E-01 8.9133E-02 1.0000E 04 1.9567E-02-3.8830E-02
1.3090 1.7665E 00 4.7333E-01 1.2881E-01 1.0000E 04 2.0582E-02-4.7896E-02
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1.3090 5.8883E-01 1.5778E-01 4.1201E-01 1.0000E 04 3.8831E-03 3.9483E-01
1.3090 3.9255E-01 1.0518E-01 3.9784E-01 1.0000E 04 1.6279E-03 3.9106E-01
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1.5708 3.0480E 00 0. 2.2045E-02 1.0000E 04-1.6212E-04-1.5465E-02
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1.5708 1.8288E 00 0. 1.1828E-01 1.0000E 04-5.1942E-04-4.5831E-02
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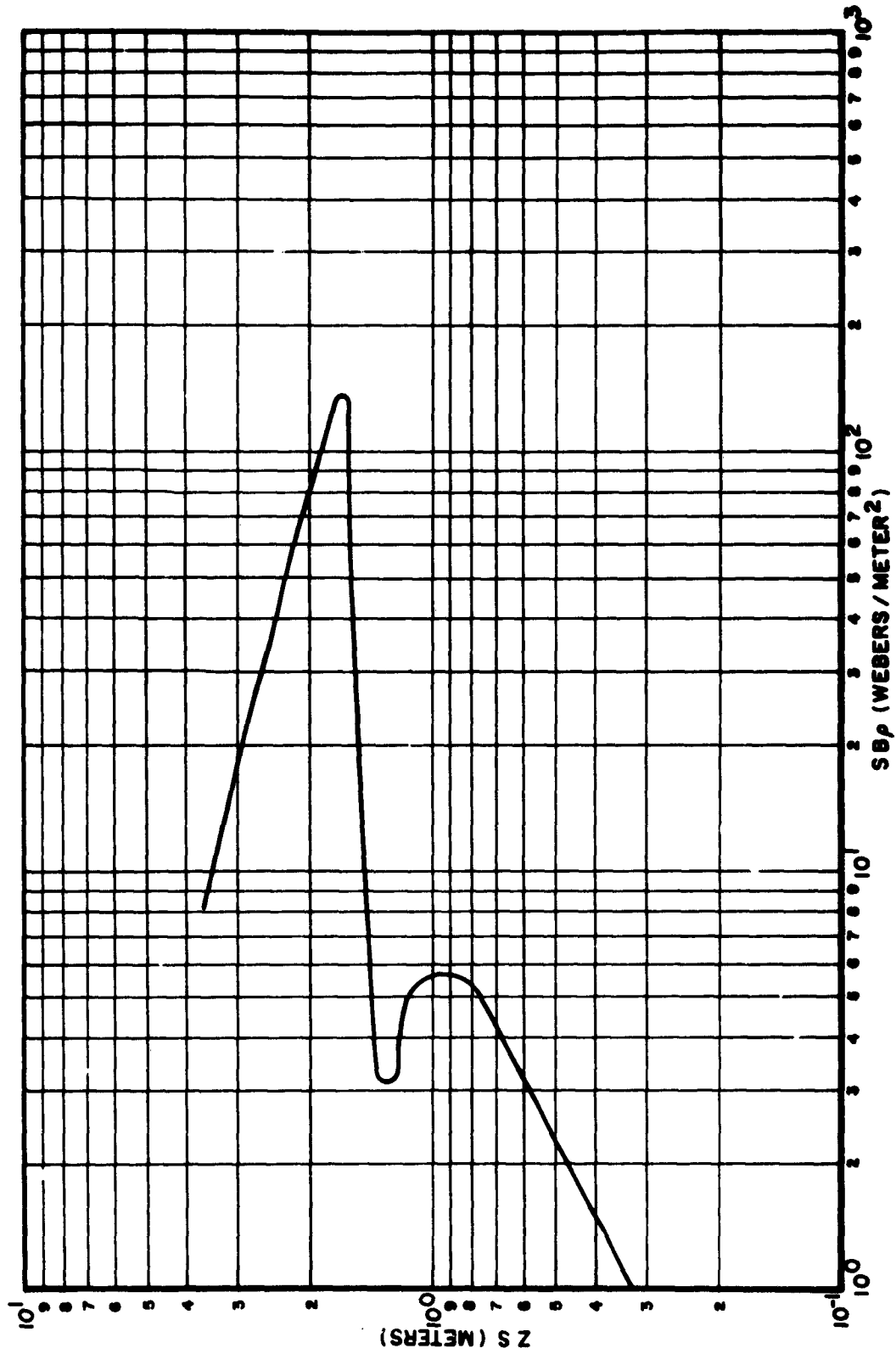


Figure IV-1. Magnetic Field Strength at 15° Off Coll Axis

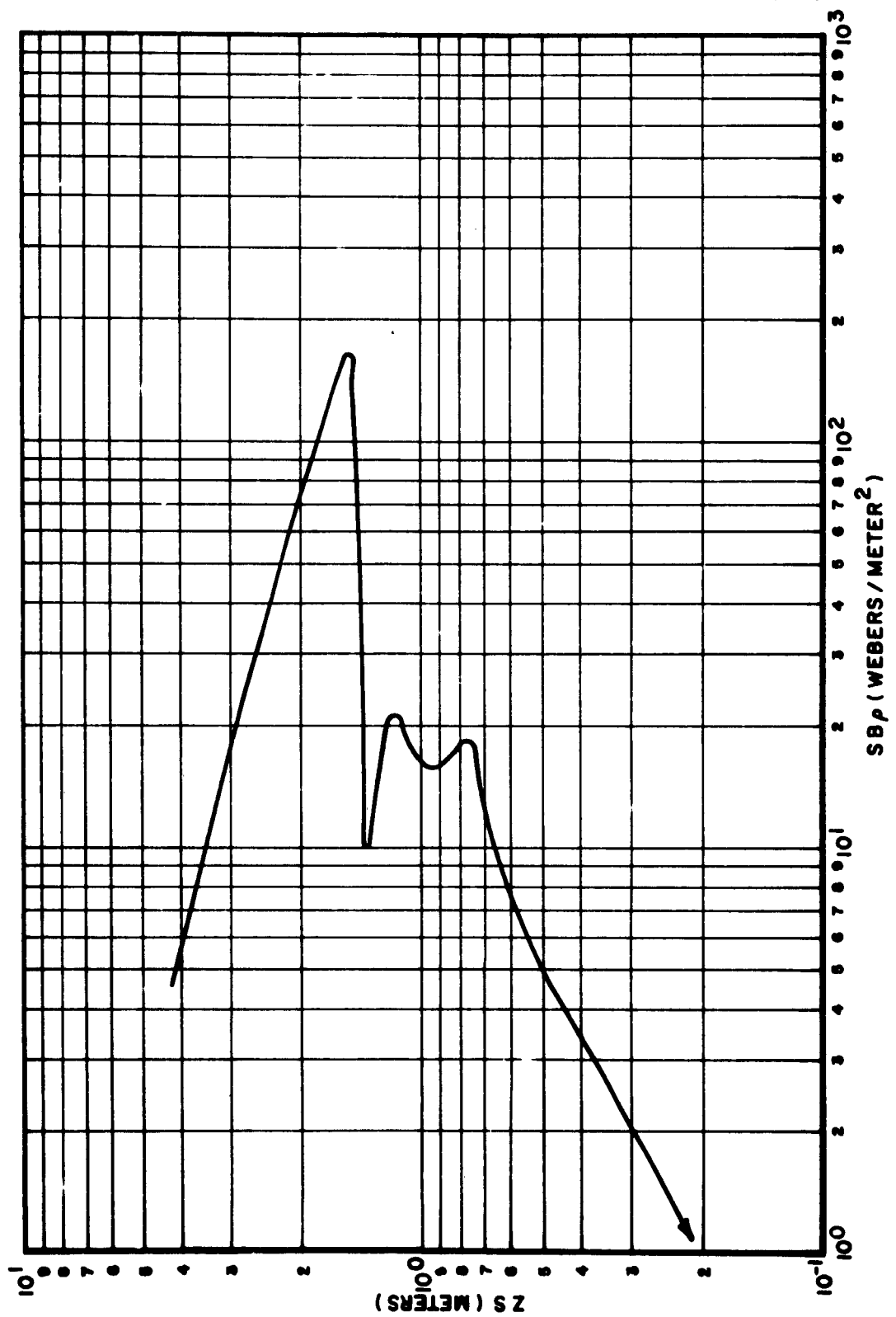


Figure IV-2. Magnetic Field Strength at 30° Off Coil Axis

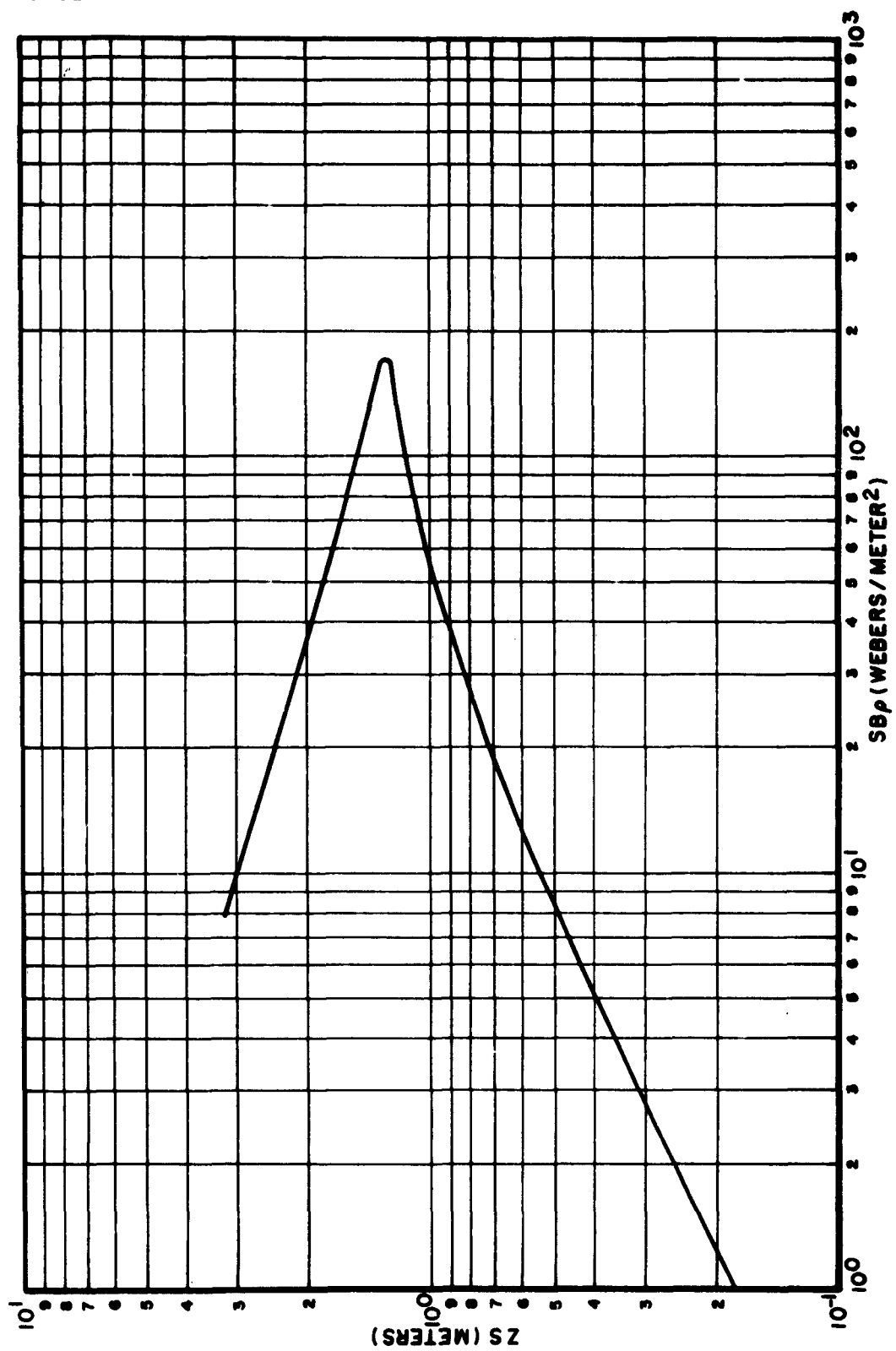


Figure IV-3 Magnetic Field Strength at 45° Off Coil Axis

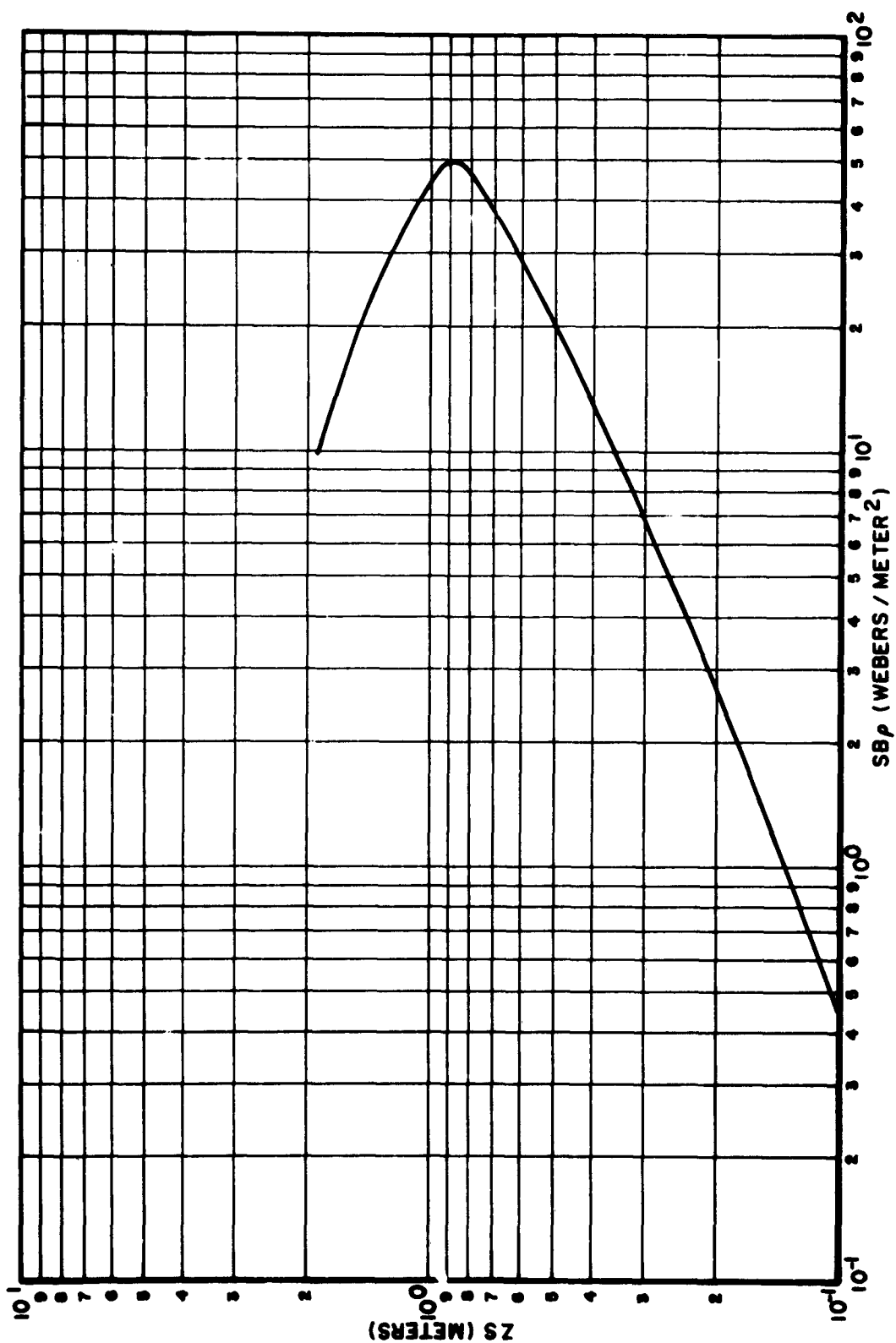


Figure IV-4. Magnetic Field Strength at 60° Off Coil Axis

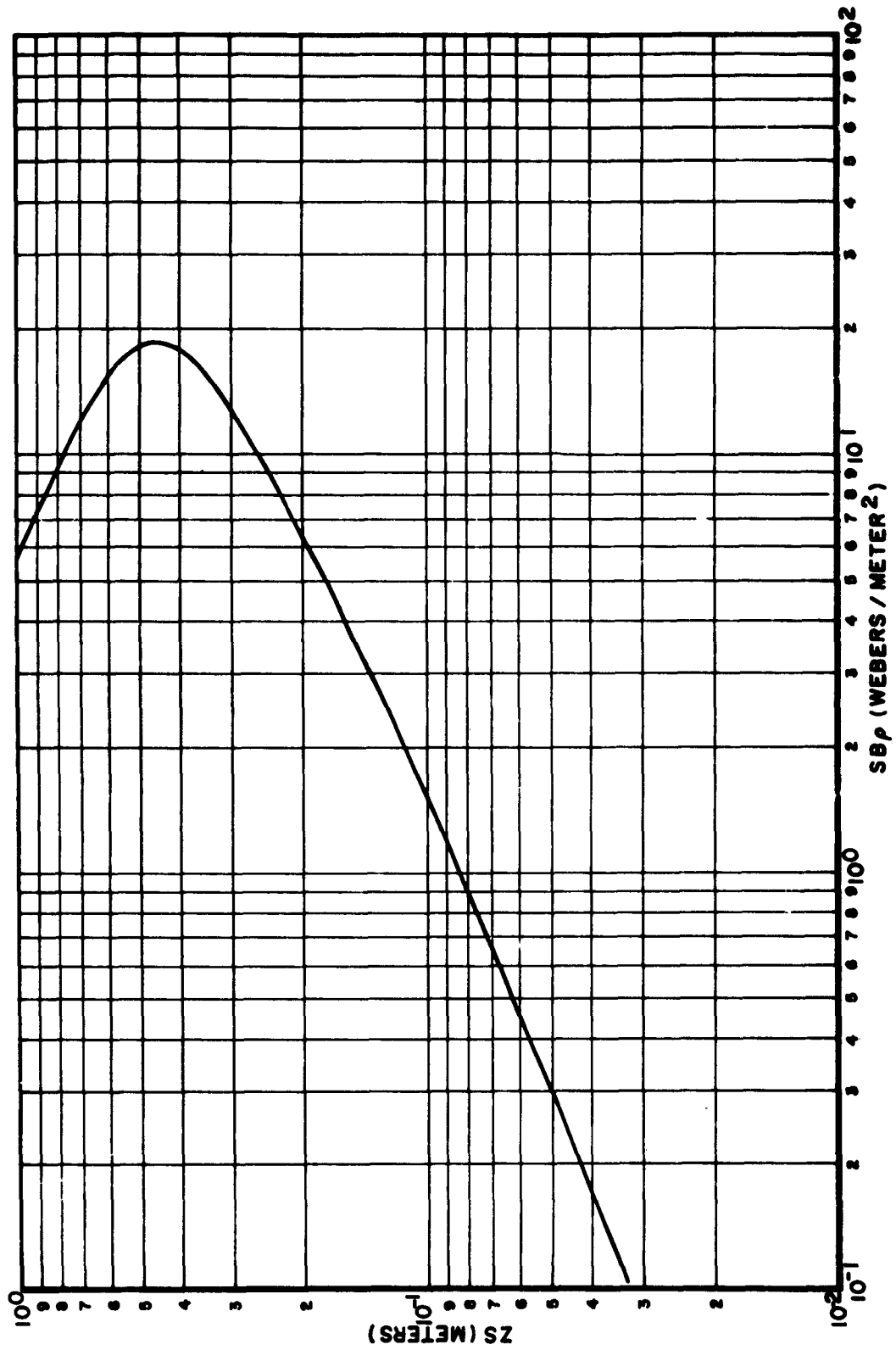


Figure IV-5. Magnetic Field Strength at 75° Off Coil Axis

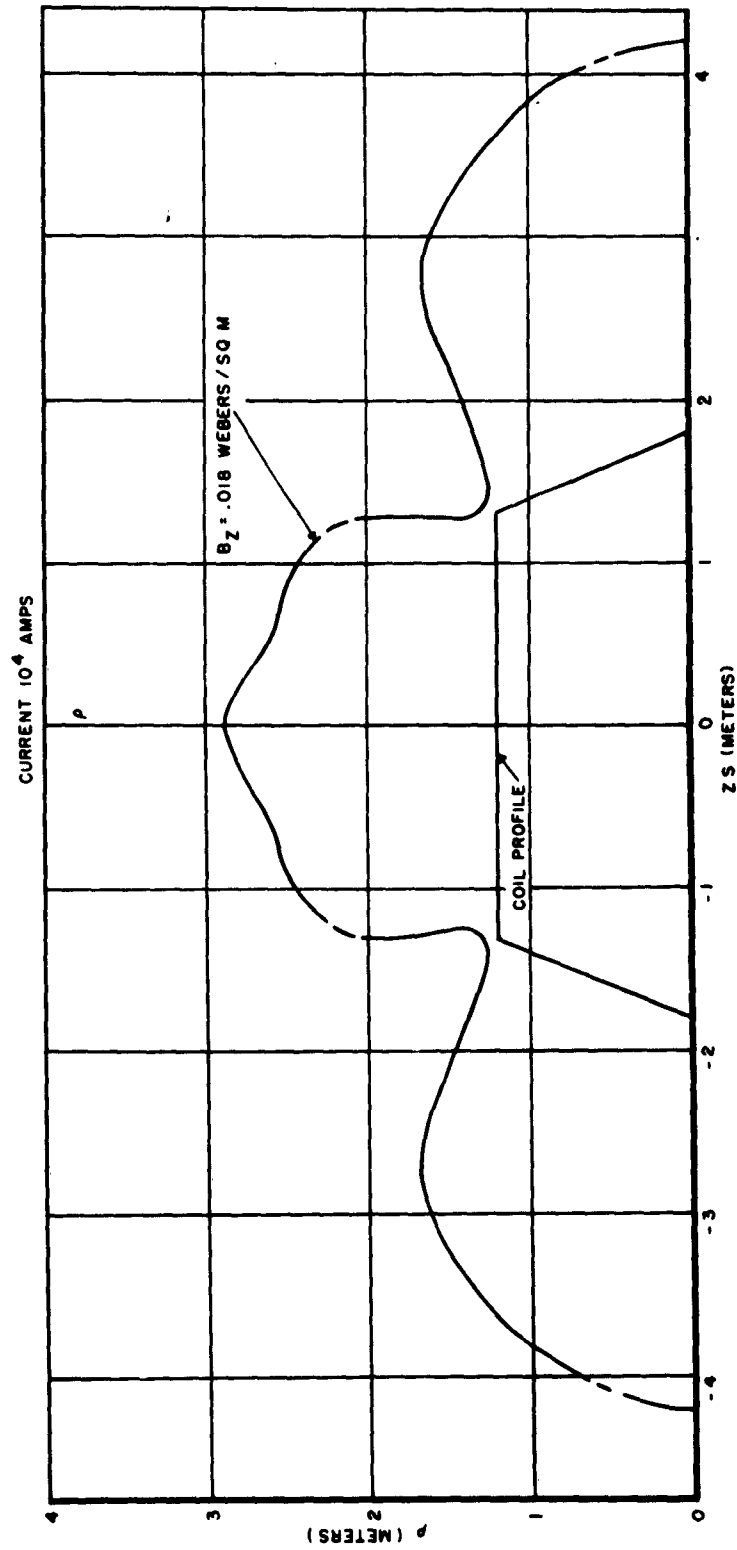


Figure IV-6. Equipotential Lines  $\rho$  Versus  $ZS$  ( $B_z = 0.018$ )

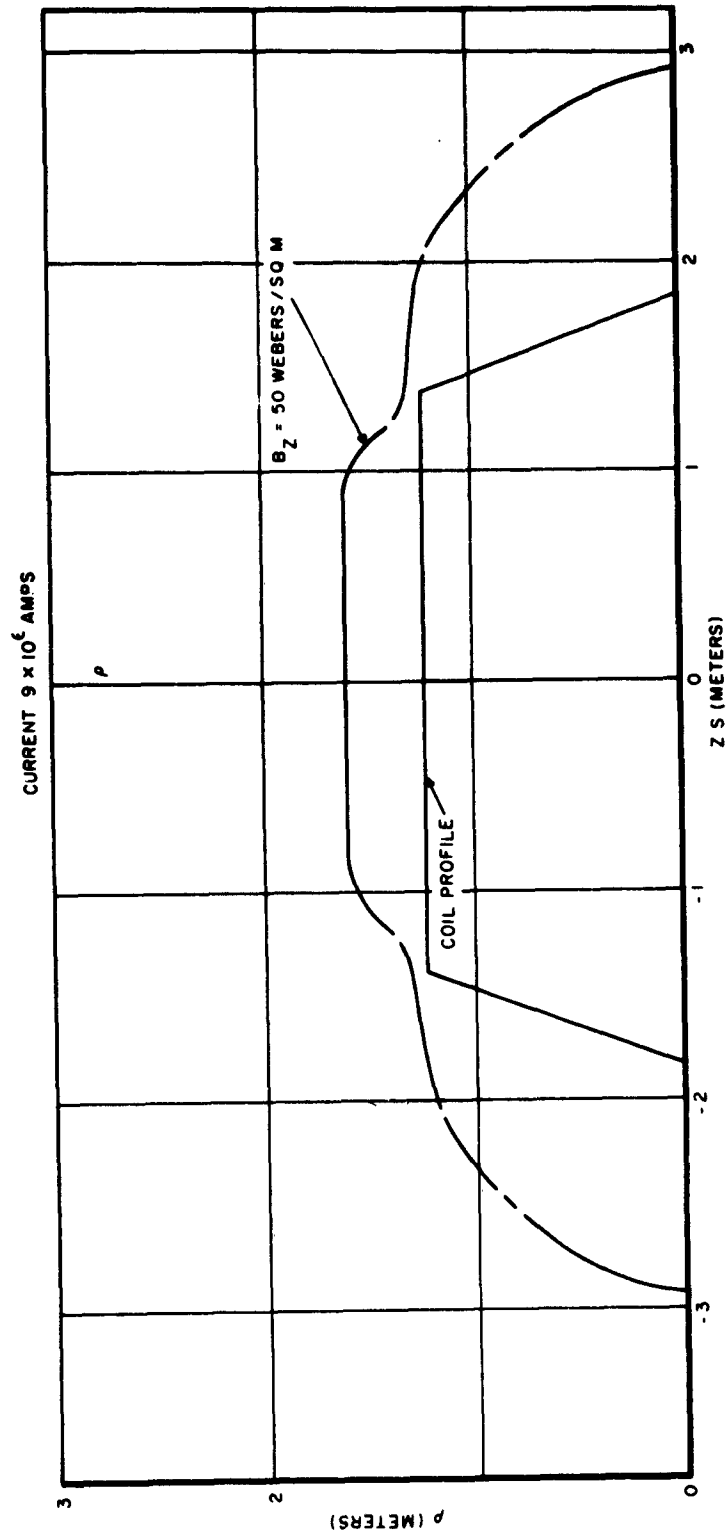


Figure IV-7. Equipotential Lines  $\rho$  Versus  $ZS$  ( $B_z = 50$ )

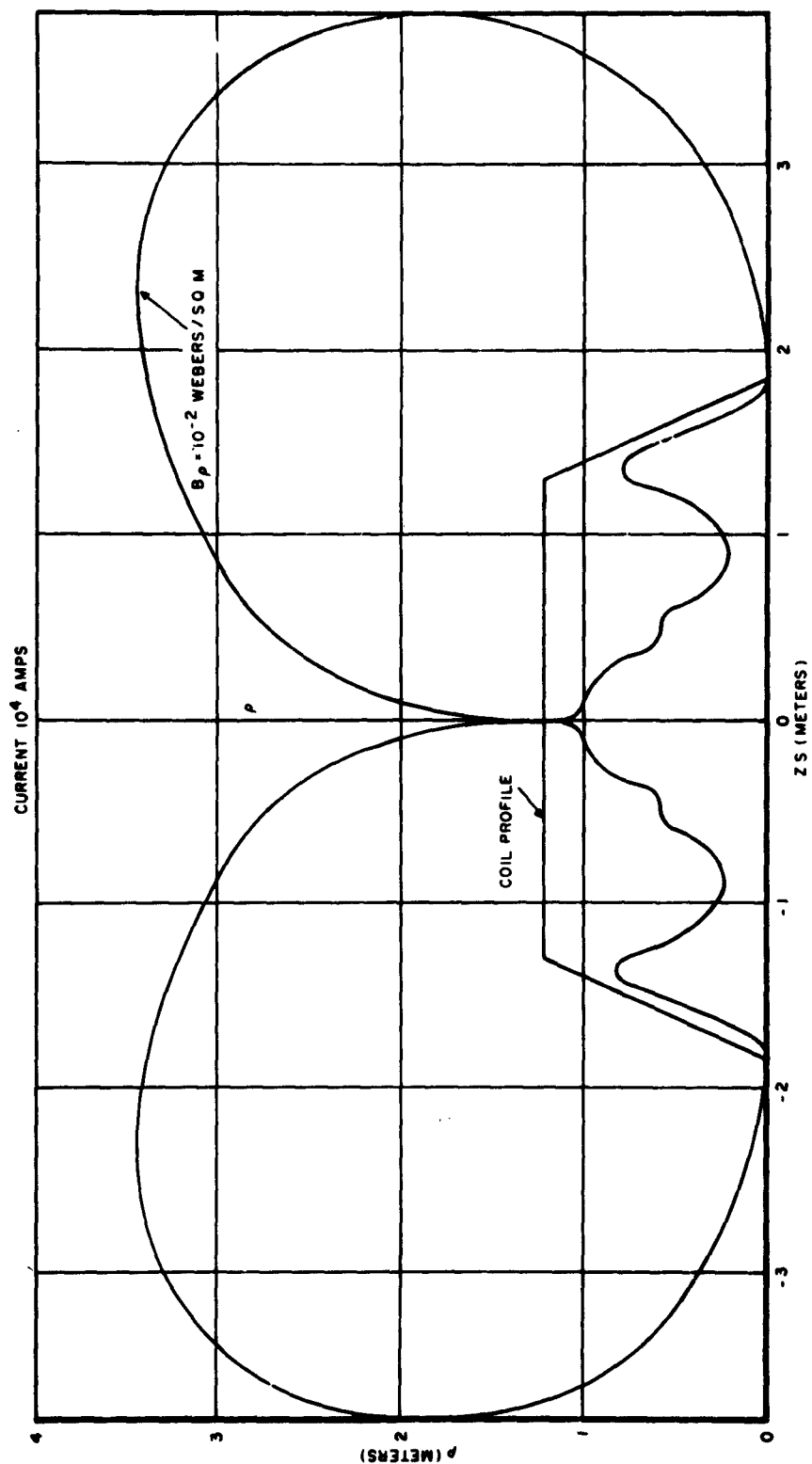


Figure IV-8. Equipotential Lines  $\rho$  Versus  $ZS$  ( $B_0 = 0.01$ )



Aeronautical Systems Division, Dir/Aeromechanics, Propulsion Laboratory, Wright-Patterson AFB, Ohio.  
Rpt Nr ASD-TDR-63-72, TECHNIQUE FOR CALCULATING TRAJECTORIES OF SINGLY CHARGED PARTICLES IN A STATIC MAGNETIC FIELD FOR SHIELDING PURPOSES, Apr 63, 83 p. incl illus., tables, 6 refs.

Unclassified Report  
The interactions between a charged particle and an externally applied static magnetic field are reviewed. The elementary effects that involve the introduction of an energetic charged particle into a magnetic field are discussed. Equations

( over )

are derived for the magnetic flux density and for calculating the trajectories of singly charged particles. Also discussed are the applications of these equations and the boundary conditions. These equations are then adapted to the Fortran program. The use of the Fortran program and the method of data input are explained. Sample problem data, a printout of the program deck, and printouts of the solutions to the problems are also presented.

1. Electromagnetic shielding
2. Electromagnetic phenomena

- I. AFSC Project 5350
- II. E. White
- III. Not aval fr OTS
- IV. In ASTIA collection

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